# DRAFT ALTERNATIVES ANALYSIS MEMORANDUM (AAM)

#### **FOR**

# TRONOX SETTLEMENT NAVAJO AREA URANIUM MINES SECTIONS 32 AND 33 MINES OF AMBROSIA LAKE SUB-DISTRICT GRANTS MINING DISTRICT, MCKINLEY COUNTY, NEW MEXICO



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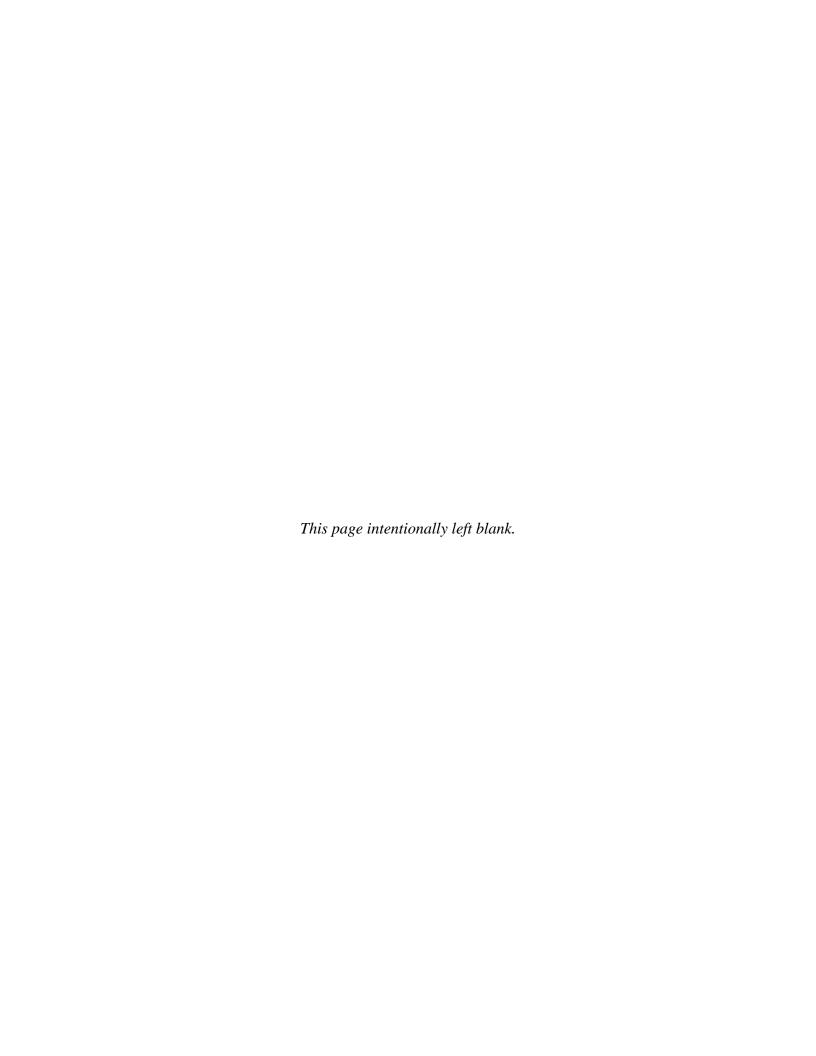
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#### ABBREVIATIONS AND ACRONYMS

ALSD Ambrosia Lake Sub-District

ARARs applicable or relevant and appropriate requirements

ASPECT Airborne Spectral Photometric Environmental Collection Technology

ASTM American Society for Testing and Materials

AT averaging time

AUM abandoned uranium mines

Bi-214 bismuth-214

BLM Bureau of Land Management (of the U.S. Department of the Interior)

BRA background reference area
BTV background threshold value

CERCLA Comprehensive Environmental Response, Compensation and Liability Act

CFR Code of Federal Regulations
CO<sub>2</sub>e carbon dioxide equivalent
COC contaminant of concern

COPC contaminant of potential concern

COPEC contaminant of potential ecological concern

cpm counts per minute
CSM Conceptual Site Model

CY cubic yards

DCGL Derived Concentration Guideline Level

DCGL<sub>emc</sub> Derived Concentration Guideline Level – elevated measurement comparison

DCGL<sub>W</sub> Derived Concentration Guideline Level – wide area

DOD Department of DefenseDOE U.S. Department of EnergyEco-SSL ecological soil screening level

ED exposure duration

EE/CA Engineering Evaluation/Cost Analysis

EMNRD New Mexico Energy, Minerals & Natural Resource Department

EPA United States Environmental Protection Agency

EPC exposure point concentration ESL ecological screening level

FRTR Federal Remediation Technologies Roundtable

GMB Grants Mineral Belt
GMD Grants Mining District
GPS Global Positioning System
GSA Geographic Sub-Area

HI hazard index HQ hazard quotient

IDW Inverse Distance Weighted

ITRC Interstate Technology & Regulatory Council

LANL Los Alamos National Laboratory

MARSSIM Multi-Agency Radiation Site Survey and Investigation Manual

MCA Multi-Channel Analyzer

mg milligrams

mg/kg milligram per kilogram
MTL maximum tolerable limit

NaI sodium iodide

NAPL non-aqueous phase liquids
NAUM Navajo Area Uranium Mines
NCP National Contingency Plan

NMAC New Mexico Administrative Code NMED New Mexico Environment Department

NMEMD New Mexico Energy and Minerals Department

NMEMNRD New Mexico Energy, Minerals & Natural Resource Department

NORM Naturally Occurring Radioactive Material

NPDES National Pollutant Discharge Elimination System

NPL National Priorities List

NPV net present value

NRC Nuclear Regulatory Commission

NRCS Natural Resource Conservation Service
NTCRA Non-Time Critical Removal Action

O&M operation and maintenance

OSHA Occupational Safety and Health Administration

OSRTI Office of Superfund Remediation and Technology Innovation

OSWER Office of Solid Waste and Emergency Response

pCi/g picocuries per gram pCi/l picocuries per liter

PEF particulate emission factor
PRG Preliminary Remediation Goal
PRP Potential Responsible Party

Ra-226 radium-226

RAML Rio Algom Mining, LLC RAO Removal Action Objective

RCRA Resource Conservation and Recovery Act

RESRAD Residual Radiation

RSE Removal Site Evaluation RSL Regional Screening Level

SEMS Superfund Enterprise Management System

SHPO State Historic Preservation Office

SLERA Screening Level Ecological Risk Assessment

SLO State Land Office

SRE Streamlined Risk Evaluation

SSL Soil Screening Level

START Superfund Technical Assessment and Response Team

TAL Target Analyte Metals

TBC to be considered

TCRA Time Critical Removal Action
TDD Technical Direction Document

T1-206 thallium-206 T1-207 thallium-207 U-235 Uranium-235 U-238 Uranium-238

U<sub>3</sub>O<sub>8</sub> triuranium octoxide

U.S. United States

USDA U.S. Department of Agriculture USGS United States Geographic Survey

UTL95-95 95% upper tolerance limit with 95% coverage UMTRCA Uranium Mill Tailings Radiation Control Act

VSP Visual Sampling Plan WESTON® Weston Solutions, Inc.

WRCC Western Regional Climate Center

#### **EXECUTIVE SUMMARY**

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START) contractor, was tasked by the U.S. Environmental Protection Agency (EPA) Region 6 under contract EP-S5-17-02, Technical Direction Document (TDD) No. 0001/17-045 to conduct activities associated with a Removal Site Evaluation (RSE) and an Engineering Evaluation/Cost Analysis (EE/CA) at the Tronox Settlement Navajo Area Uranium Mines (NAUM), Sections 32 and 33 Mines site (the Site), located in McKinley County, New Mexico (Figure 1-1). The performance period for this TDD is currently scheduled to end on 14 August 2020. The purpose of this EE/CA is to present the available data collected relative to the Site, describe the Removal Action Objectives (RAOs), describe the removal alternatives available to address contamination at the Site to meet the RAOs, and provide an analysis of the alternatives.

#### **Background and Site Description**

In November 2014, the U.S. District Court for the Southern District of New York approved a settlement agreement to resolve fraudulent conveyance claims against Kerr-McGee Corporation and related subsidiaries of Anadarko Petroleum Corporation. Among other provisions, the settlement provides EPA funding for the assessment and clean-up of over 54 Tronox NAUM sites located in EPA Region 6 and EPA Region 9 jurisdictional areas. The 22 mines in the EPA Region 6 jurisdiction area are located within the Ambrosia Lake Sub-District (ALSD). Of these 22 EPA Region 6 mines within the ALSD, only 12 mining surface operational areas are present because several of the eligible mines were operated through a common geographically central main shaft. All of these mining surface operational areas have undergone some form of closure actions and removal of surface features. Some of these mines were operated as "wet mines," in which the underground workings were dewatered to allow mining activities and the collected mine water was discharged to nearby surface drainage features such as creeks and arroyos. Little environmental data existed on the Tronox NAUM Area mines in general, nor was there data regarding risks to public health, the environment, and/or any threat abatement actions that may be necessary.

The Region 6 Tronox NAUM Area comprises approximately 100 square miles within the center of ALSD in McKinley County, New Mexico. The ALSD is located within the Grants Mining District (GMD), an area of uranium mineralization occurrence approximately 100 miles long and

25 miles wide that encompasses portions of McKinley, Cibola, Sandoval, and Bernalillo counties in the northwest part of New Mexico.

The Sections 32 and 33 Mines Site is located in the ALSD approximately 9 miles north of Prewitt, McKinley County, New Mexico (Figure 1-2). The Site area is shown on the Thoreau NE quadrangle United States Geological Survey (USGS) Topographical Map. The Site comprises two former underground uranium mines that are located in Sections 32 and 33, Township 15 North, and Range 11 West (T15N, R11W) of the New Mexico Principal Baseline and Meridian. The Sections 32 and 33 Mines Site also includes related surface areas in Sections 32 and 33 mines were developed and operated by Kerr McGee from 1960 through 1969. The mines were "dry mines" (i.e. above the water table) and did not require water to be pumped out. The current owner of the mine is reported to be Cobb Nuclear Company.

In June and July 2012, EPA Region 9 conducted a Removal Assessment of the Site. EPA delineated contamination near the waste piles in Sections 32 and 33, the shaft at the border of Section 32 and Section 33, and a "transfer area" in Section 32. In October and November 2012, EPA Region 9 conducted a Time Critical Removal Action at the Site. EPA was denied access to Section 33 by the property owner, so all removal activities took place in Section 32. EPA excavated contaminated soils from the mine area and the transfer area in Section 32. During excavation, EPA discovered two additional mine shafts. The three mine shafts were sealed and covered over with fill material. Soil removed from the excavated areas was placed in an interim stockpile located in Section 32.

Section 32 is allotment land part of the Navajo Nation. Several residences are located on Section 32, with the nearest residence located approximately 2,000 feet from the former mine site. Section 33 is privately owned and is used for livestock grazing.



Temporary Repository at Sections 32 and 33 Mines Site

#### **Nature and Extent of Contamination**

The nature and extent of the contamination was defined through surface gamma scans and subsurface soil sample collection. Based on the results of the risk assessment, the contaminant of concern (COC) for the Site is radium-226 (Ra-226). Ra-226 is typically selected as the radionuclide of interest at uranium mine sites because: (a) it is found to be a significant contributor of radiological risk to human health; (b) its decay products emit strong gamma radiation that is easy and cost-effective to measure; (c) a cleanup standard is provided in the State of New Mexico's *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico* (NMEMNRD et al, March 2016); and (d) Ra-226 is the radionuclide for which historical cleanup limits have been specified.

The total surface footprint exceeding the action level of 3.0 picocuries per gram (pCi/g) of Ra-226 (4.0 pCi/g of Ra-226 for Section 33 Naturally Occurring Radioactive Material [NORM] area) was established to be 18.8 acres, to be excavated to a depth of 2 feet. The total volume of soil exceeding the action level was determined to be 108,776 cubic yards (CY) including material in the interim stockpile (Table ES-1).

Table ES-1
Removal Volume Estimates
Tronox Navajo Area Uranium Mines,
Sections 32 and 33 Mines Site
McKinley County, New Mexico

Zone	Surface Area		Volume	
	Square		Cubic	
	Feet	Acres	Yards	
2 ft. Depth	817,455	18.8	60,552	
<b>Stockpile Footprint</b>	121,840	2.8	48,224	
TOTAL	939,295	21.6	108,776	

#### **Removal Action Objectives**

The primary objective of this removal action is to mitigate actual or potential risks to human health and/or the environment posed by excess radiological on-site contamination, and, to the extent feasible, reclaim the entire Site for the projected future land use of residential and livestock grazing. The scope of the response action will address excess radiological contamination in soil greater than the action level of 3.0 pCi/g for Ra-226 (4.0 pCi/g Ra-226 for Section 33 NORM area), which is inclusive of the Ra-226 background concentration (1.5 pCi/g [2.5 pCi/g for Section 33 NORM area]). The action levels represent total cancer morbidity risks of  $2.3 \times 10^{-4}$  and  $2.9 \times 10^{-4}$ , respectively; these risks are less than the maximum target acceptable site cancer morbidity risk of  $3 \times 10^{-4}$  (3 persons per 10,000 persons) as determined by EPA. The response action is intended to be the final action for the surface and near-surface contaminated soils/debris at the Site and to contribute to any potential remedial actions that may be contemplated for the Site through source control.

#### **Potential Removal Action Alternatives**

The following removal action alternatives were considered as part of this EE/CA. Each of the alternatives was evaluated against the criteria of effectiveness, implementability, and cost.

- Alternative 1: No Further Action included to satisfy the requirements in Section 300.430(e) of the National Contingency Plan (NCP) and to provide a basis for comparison of the remaining alternatives.
- Alternative 2: Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility – assumes that contaminated soils with concentrations of Ra-226 greater than the action levels would be excavated and disposed of off-site at a

licensed disposal facility permitted to receive the waste. Three potential licensed facilities were identified within the western United States that are authorized to accept low-level radioactive waste and/or naturally occurring low-level radioactive soil with Ra-226 concentrations ranging from 2 pCi/g to approximately 500 pCi/g.

Alternative 3: Consolidation and Capping of Contaminated Soils in Place – assumes that
radiologically contaminated soils/debris with concentrations of Ra-226 greater than the
action levels would be consolidated, and capped in place, spanning the boundary of
Sections 32 and 33. The capped area would include an engineered cover placed over the
consolidated, contaminated soils.

#### **Summary of Comparative Analysis**

#### **Effectiveness**

Alternative 1, No Further Action, does not meet removal action objectives or protectiveness standards and therefore is not effective. Alternative 2, Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility, provides a high level of long-term effectiveness; however, it has a medium level of short-term effectiveness due to the increased risk of exposure to the public and the environment from long-distance hauling to the licensed facility. Alternative 3, Consolidation and Capping of the Contaminated Soils in Place, provides a medium level of long-term effectiveness to reduce the risk to human health and the environment, since a final cap will be designed, constructed, and maintained to prevent exposure to the public and the environment. It will also provide a high level of short-term effectiveness since the hauling distance to the capped area is considerably less than Alternative 2. Administrative feasibility for Alternative 3 is medium, as subsurface contamination is not addressed by the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) (EPA, 2000b) and would thus require a unique, site-specific compliance plan.

#### Costs

Alternative 1 is not protective, and therefore is not effective.

Alternative 2 has a low level of cost-effectiveness due to the extremely high capital cost of transportation and disposal in comparison to Alternative 3. Therefore, due to the extremely high cost of this alternative, it is not considered to be technically feasible.

Alternative 3 has a medium level of cost-effectiveness compared to Alternative 2. Annual costs associated with maintenance and monitoring of the cap would lower the cost-effectiveness of this alternative compared to Alternative 2.

#### *Implementability*

No Further Action (Alternative 1) is not effective and will not be considered further since it does not meet removal action objectives or protectiveness standards. The very high cost of waste transportation and disposal of waste soil in Alternative 2 is prohibitive. Alternative 3 (Consolidation and Capping of Contaminated Soils in Place) is considered to have a medium level of implementability due to the design and construction effort associated with a cap; the necessity of a unique, site-specific compliance plan; and a removal plan that will require excavation, loading, and off-site transportation of the contaminated soil and the importing of a large volume of material to the on-site capped area to meet the removal action objectives and protectiveness standards.

#### 1.0 INTRODUCTION

Weston Solutions, Inc. (WESTON®), the Superfund Technical Assessment and Response Team (START) Contractor (EPA team), was tasked on 15 August 2018 by the U.S. Environmental Protection Agency (EPA) Region 6 under Contract No. EP-S5-17-02, Technical Direction Document (TDD) No. 0001/17-045, to conduct a Removal Site Evaluation (RSE) and an Engineering Evaluation/Cost Analysis (EE/CA) at the Tronox Settlement – Navajo Area Uranium Mine (NAUM) Sections 32 and 33 Mines site (the Site) located within the Ambrosia Lake Sub-District (ALSD) of the Grants Mining District (GMD) near Prewitt in McKinley County, New Mexico (Figure 1-1). The Superfund Enterprise Management System (SEMS) Identification Numbers assigned to the Site are NMN000908747 (Section 32 Mine) and NMN000908748 (Section 33 Mine). This EE/CA will describe and summarize work performed in support of the RSE and EE/CA field efforts and present removal alternative actions and their evaluation to be completed as part of a Non-Time Critical Removal Action (NTCRA) at the Site.

The activities conducted under the TDDs are associated with abandoned uranium mines (AUMs), including surrounding properties, and are part of an on-going program to assess and remediate Tronox-related AUMs within the GMD. A Site Area Map, provided as Figure 1-2, presents an overview of the different AUM Geographic Sub-Areas (GSAs) in the ALSD.

#### 1.1 PURPOSE AND SCOPE

The purpose of this EE/CA is to present the available data collected relative to the Site, describe the Removal Action Objectives (RAOs), describe the removal alternatives available to address contamination at the Site to meet the RAOs, and provide an analysis of the alternatives. This EE/CA was conducted following the basic methodology outlined in 40 Code of Federal Regulations (CFR) §300.415 and further discussed in the EE/CA guidance (EPA, 1993). The report is compiled in accordance with the guidance and standards established under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and guidance issued by the EPA, specifically *Guidance for Conducting Non-Time-Critical Removal Actions* (EPA/540-R-93-057, 1993); and *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA Office of Solid Waste and Emergency Response [OSWER] 9355.0-75; July 2000a). The report is divided into seven sections as described below.

- Section 1: Introduction Provides background information, summarizes the findings of previous investigations and reports, summarizes the nature and extent of contamination, and presents the results of human health and ecological risk assessments.
- Section 2: Removal Action Objectives Presents the RAOs, identifies the surface area and volumes of contaminated media, and discusses the removal action schedule.
- Section 3: Removal Action Alternatives Lists applicable or relevant and appropriate requirements (ARARs) and identifies and describes alternatives to address the removal action goals.
- Section 4: Analysis of Alternatives Provides an individual analysis of the alternatives using EPA evaluation criteria.
- Section 5: Comparative Analysis of Removal Action Alternatives Comparatively analyzes the removal action alternatives.
- Section 6: Recommended Alternative Based on comparative analysis, recommends one alternative from the listed removal action alternatives.
- Section 7: References Lists the references used in the development of this report.

#### 1.2 SITE DESCRIPTION AND BACKGROUND

The Region 6 Tronox NAUM Area comprises approximately 100 square miles within the center of the ALSD of the GMD in McKinley County, New Mexico. The following sections provide overviews of the GMD and ALSD before providing a Site-specific description and background of the Sections 32 and 33 Mines Site.

#### 1.2.1 Grants Mining District

New Mexico has the second-largest identified uranium ore reserves of any state in the United States after Wyoming (McLemore, 2007). Almost all of its uranium is found in the GMD (formerly and occasionally still referred to by various entities as the Grants Mineral Belt [GMB]), an area of uranium mineralization occurrence approximately 100 miles long and 25 miles wide, encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties in the northwest part of New Mexico. The GMD is composed of geographic sub-districts wholly within the Navajo Nation (EPA Region 9 jurisdiction), wholly within EPA Region 6 jurisdiction, and one sub-district with shared EPA Regions 6 and 9 jurisdiction – Ambrosia Lake. A Site Location Map is provided as Figure 1-1.

The GMD (hereafter to mean only those sub-districts wholly within EPA Region 6 jurisdiction or the ALSD shared jurisdiction areas) is within the Navajo and Datil sections of the Colorado Plateau physiographic province. Characteristic land features include rugged mountains, broad flat valleys, mesas, cuestas, rock terraces, steep escarpments, canyons, lava flows, volcanic cones, buttes, and arroyos (EPA, 1975). The Continental Divide extends through the northwest corner of the GMD. Thus lying east of the Divide, streams and rivers in the GMD eventually flow into the Rio Grande, one of the principal rivers of the western United States that runs through the length of central New Mexico approximately 70 miles east of the center of the GMD. Nearly all of the streams in the GMD are intermittent and flow only during periods of heavy precipitation (same).

The uranium ores in the GMD are found in the northward dipping limestone and sandstones that were tilted as a result of the Zuni Uplift, which produced the Zuni Mountains that lie south and generally parallel to the trend of the mineralized zone (Holmquist, 1970). The majority of the uranium deposits in the GMD are in sandstone formations (McLemore, 2007). The first large sandstone uranium deposit to be discovered in the GMD was found by Anaconda Company in the early 1950s using aerial prospecting on the Laguna Reservation about 32 miles east of Grants and about 8 miles north of Highway 66. This discovery, the Jackpile deposit, probably influenced other large companies to investigate the GMD area for important deposits of uranium (same).

Upon the commercial discovery of uranium in New Mexico in 1950, the GMD was henceforth the primary focus of uranium extraction and production activities in New Mexico from the 1950s until the late 1990s. Several different companies moved into the region in the 1950s, particularly oil companies. They included Anaconda Company, Phillips Petroleum Company, Rio de Oro Uranium Mines, Inc., Kermac Nuclear Fuels Corporation (a cooperative of Kerr-McGee Oil Industries, Anderson Development Corporation, and Pacific Uranium Mines, Inc.), Homestake Mining Company, Sabre-Pinion Corporation, United Western Minerals Company, J. H. Whitney and Company, White Weld & Co., San Jacinto Petroleum Corporation, Lisbon Uranium Corporation, and Superior Oil Company (McLemore, 2007; TIME, 1957). Five uranium mills, shown on Figure 1-1, operated in the GMD to process the ore into triuranium octoxide (U<sub>3</sub>O<sub>8</sub>), commonly referred to as "yellowcake." Four of the mills were in the ALSD and one was located in the Laguna Sub-District.

No uranium ore has been actively mined in the GMD since 1998, although Rio Algom Mining, LLC (RAML) continued to recover uranium dissolved in water from its flooded underground mine workings in Ambrosia Lake until 2002. The Navajo Nation, whose reservation contains much of the known ore deposits, declared a moratorium on uranium mining in 2005 (McLemore, 2007).

The GMD contains 97 legacy uranium mines and five former uranium mill and tailing disposal sites that were active during the Atomic Energy Commission uranium purchase (1940s through 1970) and beyond, until the 1990s. Over 52 million tons of uranium ore were extracted from these mines, constituting approximately 68% of the total uranium ore mined in the United States (EPA, 2015a). In the GMD alone, over 300 mining permits were issued by the State of New Mexico on lands consisting of public, tribal, and private property for mine exploration and mining operations. The extraction of uranium-bearing ore occurred through open pits, from underground workings that were extensively connected, and via solution mining (same).

The State of New Mexico has specifically identified that the 97 legacy uranium mines require assessment and possible cleanup. The mines had reportable ore production and surface expression post mining (i.e., waste rock piles, vents/shafts, physical remnants, etc.).

The EPA has identified four categories with respect to entities that should be responsible for addressing the legacy mines and operational impacts within the GMD.

- Mines associated with Jackpile National Priorities List (NPL) Site (Laguna Sub-District)
- Mines covered by the Tronox settlement (ALSD)
- Mines with potential responsible parties (PRP)
- Mines without responsible parties (orphans)

Additionally, the Homestake Mining Company NPL Site (former uranium mill) is located within the GMD near Milan, New Mexico.

The Jackpile-Paguate Mine (Figure 1-1) is located in the Laguna Sub-District on the Pueblo of Laguna. The entire mine area was added to the NPL in December 2013 and will be addressed by the EPA's Remedial Program. As stated previously, the EPA Region 6 Tronox NAUM Area lies within ALSD. A description of the ALSD is provided in Section 1.2.2.

The progress of assessment and cleanup efforts of uranium mines, mills, residential areas, and water supply sources throughout the GMD is tracked by EPA through 5-year plans located on the EPA website at <a href="https://www.epa.gov/grants-mining-district/draft-2015-2020-grants-mining-district-five-year-plan">https://www.epa.gov/grants-mining-district/draft-2015-2020-grants-mining-district-five-year-plan</a>.

#### 1.2.2 Ambrosia Lake Sub-District

The ALSD is the largest of the sub-districts within the GMD, comprising approximately 760 square miles and stretching from Interstate Highway 40 to the south, New Mexico State Highway 371 from Thoreau to Crownpoint to the west, a line 25 miles north of the Cibola County/McKinley County border to the north, and the western portion of the Cibola National Forest, and approximately 16 miles west of the McKinley County/Sandoval County border to the east. A Site Area Map is provided as Figure 1-2. As referenced above, federal removal jurisdiction is held jointly within the ALSD by EPA Regions 6 and 9. The western one-third of the ALSD is Navajo Nation (within EPA Region 9 jurisdiction) or mixed ownership and the remainder is private land under EPA Region 6 jurisdiction.

#### Geology and Hydrogeology

The ALSD is located in the southeast corner of the Navajo section of the Colorado Plateau physiographic province. The geology is characterized by elongated domal uplifts, monoclines, and broad structural platforms. The majority of the regional structure was formed during late Cretaceous period to early Tertiary period (Hilpert, 1963) and was probably accompanied by east-west directed tension that produced north- and northwest-trending faults and joints (Santos, 1970). Figure 1-3 illustrates the major fault zones of the ALSD. Uranium deposits within the ALSD occur at several stratigraphic levels within the Westwater Canyon Member of the Jurassic Morrison Formation.

Section 32/33 Mines site is located at the western edge of the ALSD near the central part of the GMD. Ore was taken from Poison Canyon Sandstone located beneath the Brush Basin Member of the Jurrassic Morrison Formation (U.S. Dept. of Interior, 1981). Boring logs for the mine were unavailable so a general overview of the local geology will be presented.

The GMD is situated on the northeastern flank of the Zuni Uplift and the southern edge of the San Juan Basin within an area referred to as the Chaco Slope. The San Juan Basin, comprising an area of approximately 10,600 square miles (27,400 square kilometers) (Kelley, 1955) is a significant geological and topographic feature that covers much of the northwest portion of New Mexico, and is an important geological and physiographic feature within the Colorado Plateau geologic province. Within the area of the GMD, rocks ranging in age from Pennsylvanian through upper Cretaceous are exposed, with surface exposures of the older rocks generally restricted to the area immediately north of the Zuni Uplift. Younger marine Cretaceous rocks cover the northerly portion of the GMD and obscure the host rocks for the uranium deposits, which were dominated by the Jurassic-aged Westwater Canyon Member of the Morrison Formation. The GMD is a westnorthwest trending belt of sandstone-hosted (and lesser limestone-hosted) uranium deposits that extends from the western edge of the Rio Grande Rift, east of the Pueblo of Laguna, westnorthwesterly to the vicinity of the city of Gallup, for a distance of more than 100 miles (161 kilometers). The belt attains a maximum width of approximately 25 miles (40 kilometers), but is more commonly 6 to 10 miles (9.6 to 16 kilometers) in width. This belt of uranium deposits includes the Laguna, Marquez, the Ambrosia Lake, Smith Lake, Crownpoint, and Church Rock subdistricts. Collectively, the deposits of the belt have provided more than 340 million pounds of U<sub>3</sub>O<sub>8</sub>, ranking as the fourth largest uranium producing region in the world (McLemore et. al., 2013), and the world's largest sandstone-hosted uranium district. Sandstone-hosted uranium deposits of the GMD are hosted primarily in the Jackpile Member, Poison Canyon sandstone (informal unit of economic usage only), and the Westwater Canyon Member of the upper Jurassicage Morrison Formation. Limestone-hosted uranium deposits have been discovered in the upper Jurassic age Todilto limestone (Wilton, 2018).

Figure 1-4 shows a portion of the Thoreau NE quadrangle displaying the former mine surface expression in a mix of local Quaternary alluvium, colluvial, and aeolian deposits on the western and upward thrust area of the Big Draw Fault. Unnamed mesas comprised of Upper Cretaceous age Mancos shale and Dakota sandstone surround the former mine footprint.

The dominating soil type in the area is the Sparank-San Mateo-Zia complex (Figure 1-5) which is derived from calcareous sandstone deposited in flood plains on valley floors and is located on valley sides (Natural Resources Conservation Service, 2015).

#### **Mining Practices**

The following description of mining practices in the ALSD was taken from, "An Overview of the Uranium Industry" (NMEMD, 1979) and from "Uranium Mining and Processing" (Kerr-McGee, undated). The uranium mines in the ALSD were conventional underground mines. A diagram of a typical underground uranium mine operated by Kerr-McGee Corporation in the ALSD is provided as Figure 1-6. Mine operations included vertical mine shafts sunk to the appropriate ore depth and a station with ancillary drifts, pockets, trenches, and sumps. Shafts were typically around 15 feet in diameter and concrete-lined, with hoisting compartments via skips to bring ore and waste rock to the surface and for the conveyance of miners and materials. Groundwater flowed to the shaft and down to a collecting sump at the bottom of the shaft where it was pumped to the surface.

Aboveground, the main pad area might include main and auxiliary buildings, a shaft-area pad with a head frame up to 100 feet high, oil and fuel storage, a power facilities area, a concrete batch plant, an ore storage pad, a materials storage yard, and a powder magazine. The main building contained the hoist room, warehouse, maintenance shops, and administrative offices.

Mine development included horizontal drifts driven outward from the shaft and beneath the elevation of the ore zones. The drifts were approximately 9 feet wide by 9 feet high and were supported by rock bolts and wood and/or steel sets. Haulage drifts generally paralleled the long axis of the ore bodies. Short drifts, called crosscuts, were driven normal to the haulage drift as required to reach the extremities of the ore bodies. As drifts extended further from the shaft, ventilation holes of 36 to 72 inches in diameter were drilled to maintain air quality, typically functioning as exhaust while the main shaft functioned as the fresh air intake. The ore bodies were outlined by longhole drilling, which were probed to determine the location of the ore and to dewater the ore bodies.

Extraction (called "stoping") of an ore body began once development was complete. Generally, there were three stoping methods employed: open stopes, room and pillar stopes, and square set stopes. The selection for each ore body depended on the stability of the ground and the size and shape of the ore body. Once mined, drifts were typically backfilled, sometimes with mill tailings, to prevent collapse.

Mine water recirculation, sometimes referred to as "in-situ stope leaching" or "solution mining," was commonly performed to ALSD mines (NMEMD, 1979). The process is described as follows. In the early years of mining, when retreat began from a worked-out area, the roof collapsed, making it difficult to further ore recovery using traditional techniques. To further increase recovery, mine owners drilled holes into the top of the collapsed zone and sprayed water through these holes onto the low-grade shattered ore. Mine water is slightly alkaline and a small amount of leaching occurs as the water runs through the shattered zone into collection sumps. The enriched water was then pumped to ion exchange plants where the uranium was removed from the water. The water was then returned for further leaching. After a period of time, no further leaching can occur. The shattered zone was then allowed to "sit" until further oxidation of the ore occurred through natural processes, usually about 2 weeks (same).

Mine-related wastes from the uranium mines commonly consist of low-grade ore of insufficient quality to process economically, overburden (waste rock) that was removed to access high-grade ore, or residuals from mine dewatering activities. Most of the mines in the ALSD conducted extensive dewatering to access ore below the water table. Most effluent from dewatering received little or no treatment before discharge to the ground or surface drainages during the majority of the mine operational period, causing perennial stream flows in major drainages that were otherwise ephemeral. Treatment of pre-discharge mine waters to extract uranium (ion exchange plants) and radium (settling ponds with bioremediation) was incorporated into most mine operations beginning in the 1970s. Other environmental impacts may have been caused by erosion and leaching of mine waste materials, some of which were deposited into arroyos where they remain today, and by the reported operation of on-site heap-leach and stope-leaching operations.

Additionally, the mine water effluent infiltrated and recharged the shallow alluvium directly or through impoundment infiltration and overflow. From 30 years of mining operations, approximately 80 billion gallons of mine water was extracted from the subsurface and discharged to surface drainages, the majority being discharged into the San Mateo Creek basin (EPA, 2015a). The effluent discharges may impact regional bedrock drinking water aquifers and shallow alluvial aquifers. These aquifers are accessed by scattered private residences and nearby municipal or community water supply systems. Moreover, extensive dewatering of underground workings during mine operations created a regionally extensive cone of depression into which oxygenated

groundwater currently is flowing. The oxygenated groundwater may dissolve and mobilize unmined uranium and associated constituents within the aquifers (same).

Most of the uranium mine sites in the ALSD have undergone some form of surface reclamation, although some mines still have physical hazards such as open adits, vent holes, and shafts, as well as uncontrolled waste rock and ore piles on-site. Some reclamations occurred prior to the New Mexico Mining Act of 1993, and all occurred prior to the promulgation of uranium mine cleanup and reclamation guidelines by the State of New Mexico in 2016. These guidelines specify a limit of 5.0 picocuries per gram (pCi/g) radium-226 (Ra-226), averaged over the first 15 centimeters of soil below the surface, averaged over any area of 100 square meters.

A total of four uranium mills operated in the ALSD (Figure 1-1). Milling activities occurred at the Phillips Petroleum Mill from 1958 to 1982, at the Homestake Mill from 1957 to 1990, at the Anaconda-Bluewater Mill from 1953 to 1982, and at the Rio Algom Mill from 1958 to 2002 (EPA, 2015a). The Department of Energy (DOE), with Nuclear Regulatory Commission (NRC) oversight, is responsible for long-term surveillance and maintenance duties at the Phillips Petroleum and Anaconda-Bluewater Mill. The NRC, in coordination with the EPA and the New Mexico Environment Department (NMED), currently regulates ongoing remedial activities at the Homestake Mill Superfund Site. The NRC also oversees reclamation in coordination with the NMED at the Rio Algom Uranium Mill (same).

#### **SEMS Sites in the ALSD**

In November 2014, the United States District Court for the Southern District of New York approved a settlement agreement to resolve fraudulent conveyance claims against Kerr-McGee Corporation and related subsidiaries of Anadarko Petroleum Corporation. Settlement proceeds were distributed in January 2015, and the EPA received funding for the assessment and subsequent cleanup of fifty (54) Tronox NAUM sites located in both EPA Region 6 and EPA Region 9 jurisdictional areas.

Twenty-two (22) legacy uranium mines, within the EPA Region 6 Tronox NAUM footprint (all located within the ALSD) are eligible for Litigation Trust funding. Of the 22 eligible mines within the ALSD, only 12 surface operational areas are associated with these mines due to several of the eligible mines being operated through a geographically shared central main shaft. All of these

mines have undergone some form of closure operations and removal of operational surface features. Some of these mines were operated as "wet mines," where the underground workings were dewatered and the collected mine water was discharged to nearby surface drainage features such as creeks and arroyos. Little environmental data currently exists on the Tronox NAUM in general, or specifically, regarding risks to public health and/or the environment, and/or any threat abatement actions that may be necessary. EPA Region 6 has been tasked to obtain the data required to evaluate the risks posed by these legacy mine sites and conduct appropriate risk abatement activities.

The Tronox NAUM Area within Ambrosia Lake is divided into three stand-alone mine sites: the Section 10 Mine, the Spencer Mine (U.S. Department of the Interior's Bureau of Land Management [BLM] lead) and the Sections 32 and 33 Mines; and three GSAs:, the East (Sections 35 and 36 Mines), Central (Sections 17, 19, 30, and 33 Mines), and West (Sections 22, 24, and 30 Mines) (Figure 1-2). The Tronox Sections 32 and 33 Mines site is located approximately 9 miles west-northwest of the Ambrosia Lake valley, but is still within the ALSD. As more information is gathered about orphan mines and mines with PRPs, further geographic sub-areas may be identified.

Land ownership within the Tronox NAUM Area varies predominantly by geographic section; that is, the vast majority of the geographic sections have one landowner. The majority of land in the Ambrosia Lake valley is privately owned, but also includes lands owned by the state of New Mexico, the BLM, and the Navajo Nation. The Sections 32 and 33 Mines Site includes one section that is privately owned (Section 33) and one section that is owned by the Navajo Nation (Section 32). Ownership of the Sections 32 and 33 Mines Site and surrounding land is illustrated on Figure 1-7.

In addition to the Tronox sites, other SEMS sites in the ALSD include the Ann Lee Uranium Mine, the John Bully Uranium Mine, the Sandstone Uranium Mine, and the Homestake-New Mexico Partners Uranium Mine (Figure 1-2). The PRP for the Ann Lee, John Bully, and Sandstone mines is United Nuclear, while Homestake Mining Company is the PRP for its namesake mine.

The Sections 32 and 33 Mines Site is the subject of this EE/CA; activities associated with the East, Central, and West GSA Mines and the Section 10 Mine will be reported under separate EE/CAs.

#### 1.2.3 Site Location

The Sections 32 and 33 Mines Site is located in the ALSD approximately 9 miles north of Prewitt, McKinley County, New Mexico (Figure 1-2). The Site area is shown on the Thoreau NE quadrangle United States Geological Survey (USGS) Topographical Map. The Site comprises two former underground uranium mines that are located in Sections 32 and 33, Township 15 North, and Range 11 West (T15N, R11W) of the New Mexico Principal Baseline and Meridian. The Sections 32 and 33 Mines Site also includes related surface areas in Sections 32 and 33 impacted by contamination from associated mining operations.

#### 1.2.4 Operational Status

The Sections 32 and 33 mines were developed and operated by Kerr McGee from 1960 through 1969. The Section 32 mine operated from 1960 through 1969 and produced 20,117 tons of ore. The Section 33 mine operated from 1960 through 1964 and produced 4,243 tons of ore. The mines were "dry mines" (i.e. above the water table) and did not require de-watering. The current owner of the mine is reported to be Cobb Nuclear Company.

#### 1.2.5 Structures, Topography, and Vegetation

The Sections 32 and 33 Mines were located on the border of Sections 32 and 33. The mines had underground workings in both Section 32 and Section 33, and shared two shafts, surface structures, and infrastructure. The Sections 32 and 33 Mines Site is referred to as the single Moe Mine or Moe #5 Mine on some maps and documents. An additional shaft was located approximately 1,300 feet south of the main shaft, in an area referred to as the "transfer area" (Figure 1-8).

The Sections 32 and 33 Mines Site has undergone some reclamation activities. The buildings and aboveground structures have been removed, presumably by the owners/operators. EPA conducted additional reclamation activities described in Section 1.3 of this report.

The Site area lies approximately 7,000 to 7,300 feet in elevation above mean sea level. It is located in a valley surrounded by unnamed mesas and within the Semiarid Tablelands. This ecoregion is characterized by dry plains, mesas, valleys, and canyons formed from sedimentary rocks. A

detailed description of site vegetation is presented in the *Natural Resources Evaluation* report (June 2019) performed by NV5, provided in Appendix A.

As discussed by NV5 (NV5, June 2019a), the Site is primarily located within Plains-Mesa Grassland and Great Basin Desert Scrub vegetation communities, with a developed shrub series component present in most areas. The following vegetative communities were identified: Juniper Savanna, Arroyo Riparian, Plains-Mesa Grassland, Great Basin Desert Scrub, Coniferous Woodland, and Disturbed. Overall plant diversity was very low across the site. Although noxious weeds are known to occur in the general area, there were no State of New Mexico Class A, B or C weeds present found during the study (NV5, 2019a).

#### 1.2.6 Site Soils

The geology of the Sections 32 and 33 Mines Site was covered previously in Section 1.2.2. The hydrology of the site is covered in Section 1.2.7.

Soils at the Sections 32 and 33 Mines Site consist of the following U. S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS, 2015) map units: Sparank-San Mateo-Zia complex, 0-to-3% slopes (soil unit: 230); Penistaja-Tintero complex, 1-to-10% slopes (soil unit: 205); Celavar-Atarque complex, 1-to-8% slopes (soil unit: 305); Berryhill-Casamero Clays, 2-to-10% slopes (soil unit: 380); Todest fine sandy loam, 2-to-8% slopes (soil unit 376); Zyme-Lockerby association, 5-to-35% slopes (soil unit: 338); and Rock outcrop Westmion-Skyvillage complex, 30-to-80% slopes (soil unit: 290). Soils are generally well drained; not hydric or slightly hydric, moderately susceptible to wind and water erosion, and occur more than 200 feet from groundwater depth (NV5, 2019a). Soil chemistry parameters were evaluated in eight soil samples as part of NV5's natural resource study. Results of the soil chemistry tests indicate the site soils have low fertility, are low in boron, are high in potash and magnesium, and have a high carbon-to-nitrogen ratio. The pH of site soils ranges from 8.1 to 8.3. These are classified as alkaline soils but are not extreme (Appendix A).

#### 1.2.7 Hydrologic Setting

The Site is within the Rio San Jose 8-digit Hydrologic Unit Code 13020207, which occurs in the larger Middle Rio Grande drainage basin. The ground near the Site slopes from east to west such

that most surface water drainage from Section 33 flows westward through an arroyo located 400 feet north of the mine site, with some drainage flowing through the site. Surface water flow from the Site occurs through a series of unnamed ephemeral streams and arroyos generally to the west into Section 32 for 0.5 miles, and then turns south flowing into Casamero Draw approximately 2.7 miles southwest of the Site (Figure 1-9). Casamero Draw flows into Mitchell Draw, which flows into Rio San Jose approximately 14 miles south of the Site (Mitchell Draw and Rio San Jose are not on Figure 1-9). The Casamero Draw, Mitchell Draw, and Rio San Jose are intermittent streams in the vicinity of the mines.

#### 1.2.8 Surrounding Land Use and Population

McKinley County, New Mexico, has a total land area of approximately 5,455 square miles and a population of 71,492 (2010 U.S. Census; American Fact Finder, data.census.gov). The closest community to the Site listed in the U.S. Census is Thoreau, 13 miles to the southwest, which has a population of 1,865. The Census Tracts immediately surrounding the Site (Census Tracts 9440 and 9460) have populations of 2,186 and 5,677 persons, respectively, with the majority of the population occurring on the Navajo Nation.

Section 32 is part of the Navajo Nation. The Navajo community of Casamero Lake is located in Section 29 of T15N, R11W, approximately 1.1 miles northwest of the Site. There are at least 19 residents in Section 32. The nearest residences are located approximately 0.3 mile east of the temporary repository. The residents in Section 32 keep livestock including horses, cattle, sheep, and goats. No gardens were noted in Section 32.

Section 33 is privately owned and used for livestock grazing (cattle).

Hunting activities are popular in the area. Although public access to the Site is moderately restricted through perimeter barbed wire fencing and locked gates, trespass hunting activities are possible.

#### 1.2.9 Historical/Cultural Resources

In consideration of future corrective actions at the Site, a cultural resource survey was conducted to meet the requirements of Section 106 of the National Historic Preservation Act. A team of

archaeologists conducted the survey of the Site between December 2018 and April 2019. The Cultural Resources Survey Report is provided as Appendix B. The survey included all of Section 32 and the western half of Section 33 (NV5, 2019b).

The Cultural Resources Survey Report has been submitted to the State Historic Preservation Office (SHPO) and the Trust Archeologist in the State Land Office (SLO) for review. EPA will also extend an invitation for cultural resources consultation to the Tribes that have identified an interest in the New Mexico SHPO in potential consultation on federal undertakings in McKinley County, New Mexico. Any further actions required by the SHPO, the SLO, or from tribal consultation will be considered during final alternative selection and included in final alternative design. A Cultural Resources Protection Plan will be developed prior to the initiation of removal activities and will include protections for historical/cultural resources documented during the survey, as applicable. The plan will include mitigation requirements determined by the stakeholders, including the SHPO and Tribes. Removal activities will be scheduled to provide adequate time to institute the mitigation activities to avoid any disturbance to the Sites visually identified until clearance is provided to the EPA.

#### 1.2.10 Sensitive Ecosystems and Wildlife

As mentioned in Section 1.2.5, a natural resources survey was performed to identify protected species and general wildlife habitat, and general vegetation and vegetative community types for the Site area (NV5, 2019a). Information gained during the survey was used during the completion of an Ecological Risk Evaluation (Section 1.5.3) including recommendations for soil amendments and seed mixtures for revegetation after excavation. A copy of the Natural Resources Evaluation Report is included in Appendix A. NV5 conducted the survey within all of Section 32 and 33. In general, wildlife was not common across the study area with fewer than 20 vertebrate species present. Some of this lack of diversity and abundance is likely due to the time of year (winter) when the surveys occurred. However, many of the lowland Great Basin Desert Scrub communities were in poor condition with stunted shrub growth and very little herbaceous ground cover. Additionally, a substantial portion of the north half of Section 32 is impacted by human activities and domestic predators such as dogs. All these factors can reduce the quality of habitat for vertebrate species (NV5, 2019a).

Only nine bird species were noted during the field surveys. Based on the topographic relief, and the abundance of woodland habitats along the eastern edge and southern boundary of the study area, birds should have been more abundant even in the winter months. Most bird observations occurred singularly; some of the corvids such as Common Raven and American Crow were in small flocks. Resident species that would be expected in such a habitat were either scarce or not present. (NV5, 2019a).

Ten species of mammals were observed in the survey area and, based on surveys of nearby areas, others would be expected. No reptiles or amphibians were observed during the field survey due to the time of year the survey was completed; however, whiptail, collared and fence lizards, and bull snakes are likely present.

No designated or proposed critical habitat occurs within the Site boundary. The CP-2 unit of designated critical habitat for the Mexican spotted owl is located approximately 24 miles southeast of the study area within the Cibola National Forest.

An Environmental Protection Plan will be developed prior to the initiation of removal activities and will identify sensitive ecological habitats and species documented during the survey. Removal activities may be scheduled to avoid certain critical periods of the year such as nesting or breeding seasons. The areas of concern will be visually identified to avoid any disturbance until clearance is provided to the EPA.

#### 1.2.11 Regional Climate

Climate at the Site can be described as semi-arid although the mountainous terrain results in a large variation of temperature and precipitation. Monthly climate data is available from 01 October 1929 to 30 November 1992 from a meteorological data station (#298830) at Thoreau, New Mexico. The average high temperatures range between 43 °F to 85 °F, and the average low temperatures range between 18 °F to 56 °F. (Western Regional Climate Center [WRCC], 2020).

There is considerable variation in monthly precipitation totals although most of the precipitation in the Site area occurs during late summer thunderstorms. Monthly precipitation generally varies between 0.45 inches (April) and 2.16 inches (August), with an annual average of 10.71 inches (WRCC, 2020).

#### 1.3 PREVIOUS REMOVAL ACTIONS

The Sections 32 and 33 Mines Site has undergone some reclamation activities. The buildings and aboveground structures have been removed, presumably by the owners/operators.

In October and November 2012, EPA Region 9 conducted a Time Critical Removal Action at the Site. EPA was denied access to Section 33 by the property owner, so all removal activities took place in Section 32. EPA excavated contaminated soils from the mine area and the transfer area in Section 32. During excavation, EPA discovered two additional mine shafts. The three mine shafts were sealed and covered over with fill material. Soil removed from the excavated areas was placed in an EPA Environmental Response Team (ERT) designed interim stockpile located in Section 32 (Figure 1-8). After excavated materials from all planned removal areas on Section 32 were placed in the interim stockpile, a soil stabilizer and dust control agent were applied to stabilize the stockpile pending further removal actions. The interim stockpile occupies an area of 121,840 square feet and has a height of 30 feet above the surrounding ground surface. The stockpile was secured with a chain link fence. Excavated areas were graded and contoured to blend with the overall topography and drainage course of the area.

#### 1.4 NATURE AND EXTENT OF SOIL CONTAMINATION

The nature and extent of the contamination was defined through surface gamma scans and subsurface soil sample collection as described in Sections 1.4.2.2 and 1.4.2.3. Based on the results of the risk assessment (Section 1.5), the contaminant of concern (COC) for the Sections 32 and 33 Mines Site is Ra-226.

#### 1.4.1 Previous Investigations

In June and July 2012, EPA Region 9 conducted a Removal Assessment of the site (Appendix C). EPA delineated contamination near the waste piles in Sections 32 and 33, the shaft at the border of Sections 32 and 33, and a "transfer area" in Section 32. The highest gamma scan measurements using a 3-inch-by-3-inch sodium iodide detector (3x3 NaI) were 962,400 counts per minute (cpm) in Section 32 and above 1,000,000 cpm in Section 33, compared to a background of 23,000 cpm. Soil samples were collected and sent for laboratory analysis of Ra-226. The background Ra-226 activity for the soil samples was 1.2 picocuries per gram (pCi/g). The highest Ra-226 specific activity in Section 32 was 37.3 pCi/g. The highest specific activity in Section 33 was 76.1 pCi/g.

In 2018, as part of the EPA assessment activities at former mine sites in the Navajo Nation, the EPA Airborne Spectral Photometric Environmental Collection Technology (ASPECT) platform (airplane) conducted an aerial gamma screening survey of the Sections 32 and 33 Mines Site (EPA, 2020). The ASPECT survey did not indicate levels of gamma radiation corresponding to soil activity levels above 3.0 pCi/g. In general, the ASPECT platform provides a broad assessment of radiological contamination at concentrations and dispersion scenarios present at sites such as the Section 32 and 33 Mines. Smaller areas of contamination and detection of radiation levels at or near the Site action levels may not have been possible at the 500-foot altitude. Results of the survey are shown on Figure 1-10.

#### 1.4.2 Current Investigations

In August of 2017, EPA initiated an RSE of the Sections 32 and 33 Mines Site, including the development of a background reference area (BRA), completion of surface gamma surveys, and collection of subsurface soil samples. The RSE was submitted to EPA in September 2019 (WESTON, 2019). The RSE determined the nature and extent of contamination above an action level of 3.0 pCi/g of Ra-226 (4.0 pCi/g of Ra-226 for Section 33 Naturally Occurring Radioactive Material [NORM] area). The following sections describe the activities included in each stage of the investigation. As discussed previously in Section 1.2.5, Section 1.2.6, Section 1.2.9, and Section 1.2.10, a natural resource evaluation and a cultural resources evaluation of the Site were also performed.

#### 1.4.2.1 Background Reference Area Study

In order to provide a point of reference by which Site conditions can be compared to "pre-mining" environments, a background radiation level was established by the EPA. Site action levels are typically established as concentrations in excess of background levels that have been characterized in carefully selected BRAs.

Selection criteria for the BRA are provided in Section 4.5 of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM [EPA, 2000b]) and include absence of contamination, and similarity in physical, chemical, geological, radiological, and biological characteristics to the contaminated areas being evaluated.

The EPA team reviewed data regarding the selection of a previous BRA utilized by EPA Region 9 at the Site during the 2012 Region 9 Removal Action (see Appendix C). Upon review, it was determined that the Region 9 BRA appeared to be located near outcrops of the Dakota sandstone, which was found to have lower gamma activity than quaternary deposits located around and upgradient of the Site. The predominant soils impacted by the Sections 32 and 33 Mines operations are quaternary deposits. Due to these observations, EPA Region 6 conducted a gamma scan survey and review of the USGS geologic quadrangle and identified an area up-gradient of the Site with no known impact from mining activities (i.e., haul roads, stockpiles) located in Section 33 of Township 15 North, Range 11 West, which was ultimately selected as the BRA. The identified BRA exhibits similar physical, chemical, geological, radiological, and biological characteristics as the Sections 32 and 33 Mines Site.

A square area of approximately 1.5 acres was selected within Section 33 to represent the BRA. On 20 June 2018, 1-minute, stationary gamma measurements using a 2-inch-by-2-inch sodium iodide (NaI) detector and a 3-inch-by-3-inch (3x3) sodium iodide NaI detector were each collected from 20 evenly-spaced points within a rectangular-shaped grid in the BRA. The starting point for the grid was randomly generated. Soil samples were co-located with the stationary gamma measurements and sent to a qualified commercial laboratory for gamma spectroscopy analysis (Appendix D).

EPA conducted radiation toxicity modeling using two different models that considered contribution to human health impacts from all of the isotopes in the Uranium-238 (U-238) and Uranium-235 (U-235) decay chains. Ra-226, a daughter product in the U-238 decay chain, was found to be the predominant contributor of radiological risk to human health (Section 2.2.1) and is the radionuclide for which historical cleanup limits have been specified.

Statistical analysis of the background data set was performed using ProUCL 5.1 (EPA, 2015b). The average concentration for Ra-226 in the 20 samples is 1.223 pCi/g, the median is 1.22 pCi/g (indicating lack of skewness), and the standard deviation is 0.131 pCi/g (Appendix E). The coefficient of variation was 0.107 indicating a homogeneous background data set in accordance with MARSSIM guidance (EPA, 2000b). The statistical analysis of the background data set, including a goodness-of-fit test, indicated that the data set was normally, lognormally, and gamma distributed. However, the normal distribution was selected as the most appropriate model. Dixon's

outlier test did not identify any outliers. A histogram, box plot and quantile-quantile plot were generated, and visual inspection indicated a well-behaving data set without outliers that confirmed a normal distribution. Finally, a background threshold value (BTV) was calculated at a 95% upper tolerance limit with 95% coverage (UTL95-95). This BTV of 1.54 pCi/g Ra-226 represents the upper limit of the background data set such that 95% of background values are less than 1.54 pCi/g with 95% confidence. The UTL95-95 was selected as an appropriate and defensible BTV because, when added to the Derived Concentration Guideline Level (DCGL), the resulting action level is within the acceptable range that EPA manages cancer risk. See section 2.2.1 for further discussion of the DCGL and the EPA acceptable cancer risk range.

The average of the 20 1-minute gamma measurements was 31,873 cpm, with a standard deviation of 726 cpm. Again, using ProUCL, a normal distribution was confirmed and a UTL95-95 of 33,612 cpm was calculated as the BTV. A summary of background laboratory analytical results and field measurements is provided in Table 1-1. The background laboratory analytical results are provided as Appendix D. The background ProUCL statistical results are provided as Appendix E.

#### 1.4.2.2 Surface Gamma Survey

As part of the RSE, the EPA determined the lateral extent of surface contamination at the Site by conducting a gamma scanning survey (June through September 2018) utilizing a 3x3 NaI detector paired with a Global Positioning System (GPS). The detector and backpack-mounted GPS unit were carried by site personnel over transects in a walk-over survey. The distances between transects varied but were generally between 50 and 100 feet. The entirety of both Section 32 and Section 33 were surveyed to verify that there was no spread of contamination to non-contiguous areas of the sections by undocumented mining activities.

The results of the gamma scanning survey were plotted in cpm on a map using color-coded icons to represent the detector measurements (Figure 1-11). Measurements were displayed in six ranges of values, two of which were relative to the BTV and the action level. Derivation of the action level in pCi/g and its conversion to cpm is described in detail in Section 2.2.1. The figure reflects areas below the BTV, areas of contamination above the BTV but below the action level, and areas above the action level. Dark green icons represent gamma readings below the BTV and action level. Light green icons represent gamma readings above the BTV and below the action level of

39,559 cpm. Icons of other colors (yellow, orange, red, and purple) represent readings above the action level. The maximum surface gamma measurement was 233,881 cpm, approximately 7 times the BTV and 6 times the action level.

The results of the gamma scanning survey were then plotted on a second map in pCi/g using color-coded icons to represent the converted measurements (Figure 1-12). Scan values greater than the BTV were converted to pCi/g using a methodology described in Section 2.2.1. The derivation of the action level is provided in the RSE and detailed in Section 2.2.1.

Figures 1-11 and 1-12 show that large areas east and southeast of the Section 33 Mine exceed the gamma survey action level of 39,559 cpm. As shown on Figure 1-9, virtually all the area south and east of the Section 33 Mine is up-gradient and the area is unimpacted by prior mine activities.

Figure 1-13 shows Section 33 with maps of geologic deposits, surface drainage direction, and gamma scanning survey results superimposed. The drainage path for surface water runoff in Section 33 flows from the eastern mesa where a Mancos Shale outcrop exists, toward the west, over alluvial materials, and eventually flowing past the temporary repository in the northwest portion of the section. Mancos Shale is documented to contain slightly elevated levels of naturally occurring radioactive material (NORM) including uranium and its decay products (DOE, 2011). As shown on the figure, areas of slightly elevated readings (light blue icons) are located downgradient of the Mancos Shale outcrop. The drainage path is contained within a black outline on the figure, and the areas of slightly elevated readings (light blue icons) also fall within that area, suggesting that the areas of slightly elevated readings are associated with surface water runoff that has transported NORM from the Mancos Shale outcrops into the down-gradient areas.

Two surface soil samples, 33-28-31-1808 and 33-29-31-1808, were collected within the drainage pathway in Section 33 in areas impacted by eroded soils from the Mancos Shale. Analytical results for both samples were approximately 2.5 pCi/g for Ra-226. The 2.5 pCi/g is considered representative of a NORM-impacted value that is approximately 1 pCi/g higher than the 1.5 pCi/g results from the BTV in Section 33 (Section 1.4.2.1). Concentrations of uranium and its decay products are documented to be in the range of 2.5 pCi/g in the Mancos Shale formation (DOE, 2011), which is consistent with the values in those samples. Therefore, the elevated readings in Section 33 that are up-gradient of the mine area and stockpile material and are unlikely to be the

result of mining activities within either section are considered to be caused by NORM eroded from Mancos Shale outcrops on the top of the mesa in the eastern area of Section 33.

Four 1-minute gamma readings were made near the locations of the two NORM background soil samples, with an average of 39,762 cpm. A revised NORM action level of 45,734 cpm or 3.9 pCi/g was established for the drainage area up-gradient of the section 33 mine (Section 2.2.1). Therefore, areas that show elevated gamma counts between 39,559 cpm and 45,733 cpm in Section 33, shown in light blue on Figure 1-13, are attributed to NORM and will not be addressed in this EE/CA per CERCLA regulations by which NORM is not to be remediated. No areas in Section 33, other than within the fenced former mine area, were above the NORM action level of 45,734 cpm.

In addition to the NORM materials encountered in Section 33, Section 32 has small areas of elevated gamma readings exceeding the action level away from the expected mine-impacted areas as illustrated in Figure 1-11. These elevated gamma reading locations were investigated and determined to be surface outcrops related to mineralized zones in the Dakota sandstone, which are also considered NORM and will not be addressed in this EE/CA per CERCLA regulations. It should be noted that a revised NORM action level was not developed for Section 32.

#### 1.4.2.3 Soil Sample Collection

The EPA Team collected surface soil samples in the Sections 32 and 33 Mines Site to verify that radioactive contamination existed in areas of elevated gamma readings. Five surface grab soil samples plus one duplicate sample and three surface composite soil samples were collected from the Site and were analyzed via gamma spectroscopy. Three surface soil samples and one duplicate were collected from the yards of residences in Section 32 (Figure 1-14). Two grab surface soil samples were collected up-gradient from the mine in Section 33 (Figure 1-15). Three composite surface soil samples were collected from waste piles located within the fenced mine footprint area in Section 33 (Figure 1-15). The surface soil analytical results are summarized in Table 1-2. Surface sample results were used in the human health and ecological risk assessments (Section 1.5).

To determine vertical extent of contamination, subsurface soil samples were collected from 07 August 2018 through 27 September 2018. Subsurface soil samples were collected from areas

that were indicated to be above the 3.0 pCi/g action level by the gamma survey and were distributed throughout the surface-contaminated areas using the Visual Sample Plan (VSP) program (Pacific Northwest National Laboratory, Version 7.7). The samples were collected at a density of one sample for each 8 acres. The samples were collected by digging a 1-foot-deep hole and collecting a sample from the bottom of the hole using a bucket auger.

Subsurface soil samples were collected from five locations with one duplicate in Section 32 (Figure 1-14) and were analyzed via gamma spectroscopy. Subsurface soil samples were collected from four locations in the fenced mine footprint area of Section 33 (Figure 1-15); subsurface sample locations did not include the waste piles within the fenced area.

The soil samples were dried, ground/pulverized as necessary, and sieved, then analyzed in EPA's field laboratory using gamma spectroscopy with an on-site Multi-Channel Analyzer (MCA) for Ra-226. The MCA measured the gamma radiation emitted by Bismuth-214 (Bi-214) rather than Ra-226, since Ra-226 does emit a strong gamma signal. Samples were held in a sealed Marinelli jar for a minimum of 21 days to ensure that the Bi-214 and Ra-226 were in equilibrium before being analyzed on the MCA. Seven of the samples (35% of total surface and subsurface samples were sent to an off-site analytical laboratory as verification of the on-site MCA results. Sample results ranged from 1.53 to 52.7 pCi/g. The subsurface soil analytical results are summarized in Table 1-3. Subsurface sample results were used to determine an estimated removal volume after an action level was developed for the Site (see Section 2.2.1).

Additionally, eight surface samples plus one duplicate sample were collected and submitted to Hall Environmental Analysis Laboratory (Hall Laboratory) in Albuquerque, New Mexico, for Total Analyte List (TAL) metals plus uranium analysis. The metals analytical results were used in the human health and ecological risk assessments (Section 1.5) and are provided in Table 1-4. The Hall Laboratory analytical data package is provided as Appendix F.

#### 1.4.2.4 Conceptual Reclamation Plan

A conceptual reclamation plan based on current conditions and projected post-removal conditions was developed for the remediation actions contemplated by this EE/CA. The final reclamation plan will be developed for implementation after reviewing and updating as necessary the conceptual reclamation plan with actual post-removal conditions. The conceptual reclamation plan

is composed of two parts: (1) site-specific, natural regrading, modeling runs developed using Carlson Natural Regrade with GeoFluv<sup>TM</sup> (a fluvial geomorphic landform design algorithm); and, (2) the draft conceptual revegetation plan.

## **Conceptual Natural Regrading Plan**

A conceptual site-specific natural regrading plan was developed using topographical data gathered during the RSE and projected excavation values. The term "natural regrading" is defined as using fluvial geomorphic landform design algorithms to develop site-specific reclamation plans that return the topography of the site to a pre-disturbed (pre-mining) natural state. This method subscribes to the theory that prior to disturbance by man, the natural contours of the Site were in balance with the hydrology and resulted in a stable landform. The benefits of using the reclamation plan developed through the Carlson Natural Regrade software would be to provide erosion-resistant slopes and stream channels; efficiencies in the utilization of on-site materials for contouring; placement of infrastructure to minimize environmental impact and increase efficiency; and a decrease in long-term operation and maintenance costs.

Currently, surface water drainage from Section 33 flows through a series of unnamed ephemeral streams and arroyos to an unnamed arroyo in the northwest corner of the section, near the former location of the Section 33 Mine and the current location of the temporary repository. Surface water then flows through the unnamed arroyo generally to the west into Section 32 for 0.5 mile, and then turns south flowing into Casamero Draw approximately 2.7 miles southwest of the Site (Figure 1-9).

The conceptual site-specific model produced by the Carlson Natural Regrade software indicates that the most stable hydrology for the Site and surrounding areas would consist of multiple channels from Section 33 converging into a single channel within Section 32 (Figure 1-16). The channel morphology design (i.e., river pattern, longitudinal, and cross-section profiles) is related to relatively small, but frequently recurring annual flood events. The channel is shaped to keep its sediment load and stream flow in balance during these low-flow events and during extreme events. The landforms depicted in the model output provide longitudinal slopes from ridgelines in a convex-to-concave design to prevent straight gradients. The channel shown in Figure 1-16 is applicable to Alternative 2 (Section 3-5). This procedure could also be used for Alternative 3 (Section 3-6), but the site-specific model would be developed around the materials capped in place.

The final site-specific regrading plan will update the conceptual plan by calculating all the post-excavation and restoration requirements and provide the constructors with a cut and fill plan that best uses materials present on-site. The final grading plan will be exported to GPS-machine-controlled heavy equipment to more accurately execute the plan.

#### **Site Restoration**

Based on the results of the site-specific conceptual natural resources evaluation (Appendix A) and the associated soil and vegetation sample analytical results, NV5 provided recommendations to minimize the impact to wildlife during cleanup. A conceptual revegetation plan will be prepared prior to the commencement of cleanup activities. The assumed objectives considered in developing the conceptual revegetation plan will be grazing capacity, improve suitability for wildlife use, and develop a sustainable ecosystem. The conceptual revegetation plan will comply with the standards of:

- NMED and NMEMNRD Joint Guidance for Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico, March 2016 (Attachments 1 and 2).
- New Mexico State Land Office Reclamation Plan for State Mineral Lease Rule 5 Template (7-14-15).

A conceptual revegetation plan details the proper times of the year for specific activities to minimize the disturbance to wildlife and to maximize the potential for plants to become established. The plan also specifies soil amendments and nutrients to prepare the soil for reseeding, the use of specific seed mixes in each unit, mulching, and watering schedules.

#### 1.5 HUMAN HEALTH AND ECOLOGICAL STREAMLINED RISK EVALUATION

Streamlined risk evaluations (SRE) were performed to evaluate the potential impacts of Sitederived contaminants on human health and the environment in the event that no cleanup action is taken. Results of the human health and ecological risk assessments were used to determine whether residual levels of contaminants in site media are protective of human health and the environment and may be left in their current state, or if a cleanup action should be considered. Calculations and methodology used in performing the human health and ecological SRE are described in Appendix G.

## 1.5.1 Screening to Identify Contaminants of Potential Concern

Analytical results of soil samples collected during the RSE at the Sections 32 and 33 Mines Site (WESTON, 2019) served as input data for the human health and ecological SREs. These samples were analyzed for radioisotopes via gamma spectroscopy, and some samples were also analyzed for TAL metals. The metals analysis was performed to assess the actual or potential risk from subeconomic or proto-ore, which was brought to surface during the mining operations but was not sent to the mill for further processing. The analytical results used in the human health risk evaluation are summarized in Appendix G, Tables G-1 and G-2. All of the metals sampling results were screened against the EPA (EPA, 2019a) Regional Screening Levels (RSLs) (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables), New the Mexico Environment Department (NMED, 2019) generic soil screening levels (SSLs) for residential land use, and the local background concentrations to determine the contaminants of potential concern (COPCs). Table G-2 summarizes the metals data screening process, showing contaminants that were considered, the minimum and maximum concentrations detected, associated RSLs and background concentrations. It either identifies each contaminant as a COPC or explains why it was screened from consideration. Aluminum, cobalt, and manganese exceeded RSLs but did not exceed background levels. While the maximum concentrations for arsenic (6.5 milligrams per kilogram [mg/kg]) and iron (26,000 mg/kg) exceed their respective mean background concentrations (5.9 and 20,898 mg/kg, respectively), they do not exceed two times their respective means. Arsenic and iron are considered to be representative of background. Uranium had one detected concentration (21 mg/kg) above the RSL and background and was evaluated further. Uranium (as a metal) and the radioisotopes of the U-235 and U-238 decay chains were carried through an SRE to determine if they should be identified as COCs to be addressed in a cleanup action.

A separate screening procedure was performed in the ecological streamlined risk evaluation. The results of the screening level ecological risk characterization are included in Appendix G, Table G-4 for radionuclides and Table G-5 for metals. Literature-based ecological screening benchmark values for direct contact and food-chain evaluations are used to characterize potential ecological effects. The ecological streamlined risk evaluation is detailed in Section 1.5.3.

#### 1.5.2 Human Health Streamlined Risk Evaluation

The potential for adverse health effects on human receptors was assessed for radionuclides (i.e., Ra-226) and other non-radionuclide chemicals identified as COPCs in soil at the Sections 32 and 33 Mines Site (i.e., uranium). Cancer is the major effect of concern from radionuclides. The potential excess lifetime cancer risk on human receptors from exposure to radium in soil was assessed for the Sections 32 and 33 Mine Site. Noncancer effects were also assessed for uranium as a metal. Radionuclides and other chemicals in the soil may be incidentally consumed by livestock, wildlife and humans. Persons traversing the Site may be exposed to contaminated dust by inhalation of particulate matter. Whole body (external) radiation may be experienced by nearby residents and trespassers on or near the Site itself.

The Site is currently undeveloped; Section 32 is part of the Navajo Nation (Casamero Lake Chapter) and Section 33 is privately owned. Currently, four occupied residences are located approximately 2,000 feet west of the former mine surface expression. It is deemed likely that this residential portion of the Site will continue and possibly expand in the future. The risk to a resident from potential exposure to isotopes of the U-235 and U-238 decay chains and the noncancer effects from uranium (as a metal) were evaluated at the Sections 32 and 33 Mines Site.

#### 1.5.2.1 Human Health Streamlined Risk Evaluation Assumptions

Cancer risk estimates were calculated based on a residential land-use scenario for isotopes in the U-235 and U-238 decay chains (calculated from measured Ra-226 concentrations in soil) and noncancer risk estimates were calculated for uranium as a metal. The resident is assumed to be exposed to radiological contaminants via the following pathways: incidental ingestion of soil, external radiation from contaminants in soil, and inhalation of fugitive dust (EPA, 2019b). The resident is assumed to be exposed to chemical contaminants via the following pathways: incidental ingestion of soil, dermal contact with soil and dusts, and inhalation of dust (EPA, 2019a). Residential use assumes substantial soil exposure (especially for children) and long-term exposure. The residential receptor is assumed to spend most, if not all, of the day at home except for the hours spent at work. It was assumed that due to the generally arid conditions of the site and observations of current residential activity, no home-grown produce will be consumed and thus contribute to radiation exposure. The risk from radon inhalation in an indoor atmosphere is outside

the scope of this EE/CA; it will be addressed using the methodology outlined in the report *EPA Assessment of Risks from Radon in Homes* (EPA, 2003). Note that a radon inhalation pathway for outdoor radon is not addressed (as opposed to *indoor* radon, which is) in EPA's guidance on conducting radiological risk assessments at CERCLA sites (EPA, 2014). An EPA review of radon data collected at uranium mine and mill sites in the vicinity of the Site verified that clean-air dilution of radon emissions from those sites rapidly reduces the airborne concentrations to inconsequential levels (less than the EPA recommended limit for indoor concentrations of 4 picocuries per liter [pCi/I]) (Rio Algom Mining, 2016).

The risk characterization considered all isotopes of the U-235 and U-238 decay chains defined by the EPA Preliminary Remediation Goal [PRG] Calculator for Radionuclides (EPA, 2019b). The human health SRE identified Ra-226 as the most significant radiological human health COPC. Ra-226 is typically selected as the radionuclide of interest at uranium mine sites for the following reasons: (a) it is found to be a significant contributor of radiological risk to human health, (b) its decay products give off strong gamma radiation that is easy and cost-effective to measure, (c) a cleanup standard is provided in the State of New Mexico's *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico* (NMEMNRD et al, March 2016), and d) Ra-226 is the radionuclide for which historical cleanup limits have been specified. Since soil samples were collected from two sections (i.e., Section 32 and Section 33), risk was characterized by section. Additional human health risk assumptions and details about the SRE process are presented in Appendix G.

#### 1.5.2.2 Human Health Risk Estimates

Screening levels can be used to estimate the total risk from multiple contaminants at a site as part of a screening procedure. The PRG Calculator was used to calculate residential radionuclide PRGs for children and adults. Residential noncancer RSLs were developed for uranium based on a target noncancer hazard quotient (HQ) of one. Applying the PRGs, the sum-of-ratios approach was used to estimate human health risk by dividing the section-specific exposure point concentration (EPC) by its exposure-route-specific PRG and multiplying this ratio by 10<sup>-4</sup> (1E-04) to calculate a cancer risk estimate. Individual cancer risk estimates are summed to represent a total cancer risk for each section. For noncancer hazard estimates, the site-specific concentration is divided by its noncancer-based screening level and the ratios are summed for multiple contaminants to represent

a noncancer hazard index (HI). A HI of 1.0 or less is generally considered "safe." A ratio greater than 1.0 suggests further evaluation may be needed (EPA, 2019a). Applying maximum and average (mean) Ra-226 concentrations, risk estimates were calculated to assess the range of potential risk for a resident potentially exposed to radionuclides in soil. EPA manages risk to achieve 10<sup>-6</sup> to 10<sup>-4</sup> overall excess cancer risks. The excess cancer risks and noncancer HIs associated with soil sampling results from the 0 to 2 foot depth interval were considered to represent the current risk to a resident living directly on the waste area should no removal actions occur. As shown in Appendix G, Table G-1, the current total cancer risk for isotopes of the U-235 and U-238 decay chains for the Sections 32 and 33 Mines Site exceeds the 10<sup>-4</sup> excess cancer risk level in both Section 32 and Section 33. Section 32 total cancer risks in surface and subsurface soils were 2E-04 and 3E-04, respectively. Section 33 total cancer risks in surface and subsurface soils were 4E-03 and 4E-04, respectively. These results indicate the need for a response action to control releases and prevent radionuclide exposure. Note that these risk estimates also include contribution of background levels as calculated from the Ra-226 BTV of 1.5 pCi/g of Ra-226 (2.5 pCi/g of Ra-226 for Section 33 NORM) (Appendix G, Table G-1). It should be noted further that the PRG Calculator default value for lifetime exposure for a residential land-use scenario used in these calculations, is 26 years, including 6 years as a child and 20 years as an adult. The Navajo Nation government, however, leases Navajo allotment lands to eligible Navajo for residential purposes for 75 years. Substituting 75 years (6 years as a child and 69 years as an adult) for lifetime residential exposure in the PRG Calculator would have the effect of increasing the total cancer risks in surface and subsurface soil approximately three-fold, exhibiting an even greater need for a response action to control releases and prevent radionuclide exposure.

As shown in Table G-3, the noncancer hazard index for the most conservative resident (child) was 1 (when rounded to one significant figure) based on the single uranium detection. Based on the limited metals dataset, the potential for noncancer health effects from uranium is not expected to be a concern because the non-cancer hazard index for uranium does not exceed unity. When dealing with noncarcinogens, EPA guidance states that the noncancer averaging time (AT) is to be set at the same length as the exposure duration (ED), essentially cancelling out the AT and ED terms in the RSL equation. As a result, increasing lifetime exposure to 75 years, to accommodate a Navajo-specific lifeway as described above, would yield the same non-cancer hazard index. Regardless, it is anticipated that site actions to address radionuclide exposure by human receptors

will be protective for exposure of human receptors to both radionuclides and non-radionuclide chemicals due to the colocation of uranium and its decay-chain progeny (includes Ra-226).

## 1.5.3 Ecological Streamlined Risk Evaluation

The Sections 32 and 33 Mines Site is located in a remote area with the revegetated, previously disturbed mine area potentially providing habitat for ecological receptors. Wildlife inhabiting the Site may directly ingest radionuclides and chemicals, which may then be transported to organs or other sites within the wildlife receptors. Radionuclides and chemicals in the soil may be absorbed by plants consumed by wildlife. Radionuclides such as uranium and daughter progeny including radium may be inhaled on dust particles, creating alpha-particle-emitting sources in the lungs of wildlife receptors. A screening level ecological risk assessment or SLERA (i.e., Steps 1 and 2 of the EPA's 8-step ecological risk assessment process [EPA, 1997]) was performed as the ecological SRE to assess potential risk to ecological receptors from both radionuclide and non-radionuclide chemical contaminants. The results of the screening level ecological risk characterization are included in Appendix G, Table G-4 for radionuclides and Table G-5 for metals. A refinement of conservative screening level assumptions (i.e., Step 3a of the EPA's 8-step ecological risk assessment process [EPA, 2001]) was also performed to consider how the risk estimates would change if more realistic assumptions were used. The results of the refined ecological risk characterization are included in Appendix G, Table G-6. The process and conclusions are described below.

#### 1.5.3.1 Ecological Risk-Based Screening Values

Literature-based ecological screening benchmark values for direct contact and food-chain evaluations are used to characterize potential ecological effects. The following sources were used to identify proposed ecological screening benchmark values for radionuclides and non-radionuclide chemicals:

- EPA Ecological Soil Screening Levels (Eco-SSLs) (EPA, 2019c)
- Los Alamos National Laboratory (LANL) ECORISK database, Release 4.1 (LANL, 2017).
- USEPA Region 4 Ecological Risk Assessment Supplemental Guidance (2018) Soil Screening Values for Hazardous Waste Sites

https://www.epa.gov/sites/production/files/201803/documents/era\_regional\_supplemental\_guidance\_report-march-2018\_update.pdf).

- NMED (2017). Risk Assessment Guidance for Site Investigations and Remediation.
   Volume II -Soil Screening Guidance for Ecological Risk Assessments. March 2017. Tier 1 ecological screening level (ESL).
- Sheppard, Steve C., Marsha I. Sheppard, Marie-Odile Galler and Barb Sanipelli. 2005. Derivation of ecotoxicity thresholds for uranium, Journal of Environmental Radioactivity, Volume 79 (1), pages 55-83).

The Eco-SSLs include values for plant, soil invertebrate, bird, and mammal exposure to metals through direct contact and the food chain. The Eco-SSLs are based on no-effect toxicity values to (1) ensure risks are not underestimated, and (2) provide a defensible conclusion that a negligible ecological risk exists or that certain contaminants and exposure pathways can be eliminated from consideration (EPA, 1997).

The LANL ECORISK database includes ESLs for avian, mammalian, earthworm, and plant exposure models for radionuclides and non-radionuclide chemicals in soil. The LANL ECORISK database provides both no-effect and low-effect ESLs. The no-effect ESL is protective of wildlife populations and sensitive individuals because it represents an exposure that is not associated with adverse impacts of low-level, long-term chemical effects (i.e., adverse effects on ability of individuals to develop into viable organisms, search for mates, breed successfully, and produce live and equally viable offspring). The low-effect ESL applies a lowest-observed adverse-effect level-based toxicity reference value that is the lowest chronic effect level and is generally considered to be protective of wildlife populations (LANL, 2017).

The NMED has developed Tier 1 ESLs protective of the plant community, deer mouse, horned lark, kit fox (evaluated at sites greater than 267 acres), pronghorn (evaluated at sites greater than 342 acres), and red-tailed hawk (evaluated at sites greater than 177 acres). The key receptors selected as the representative species represent the primary producers as well as the three levels of consumers (primary, secondary, and tertiary) for the most common receptors found at hazardous waste sites in New Mexico. For plants, the Tier 1 screening level is based on an effect concentration for plant communities. For wildlife receptors, the Tier 1 screening level is based on NOAEL-based toxicity reference values (NMED, 2017).

EPA Region 4 (EPA, 2018) has compiled soil screening values that are intended to protect plants, soils, invertebrates, avian wildlife, or mammalian wildlife as reported from various sources. The study by Sheppard et al (Sheppard et al. 2005) summarizes the literature available to set predicted no-effect concentrations (PNECs) for chemical toxicity of uranium to non-human biota.

#### 1.5.3.2 Ecological Risk Estimates

Screening level risk characterization was performed using the HQ method to compare maximum soil concentrations to Eco-SSLs and no-effect ESLs. An HQ of less than one indicates that the concentration is unlikely to cause adverse ecological effects. An HQ greater than one indicates that the potential for ecological risk is present and the risk assessment process should continue (EPA, 2005). The screening process considered the isotopes of the U-235 and U-238 decay chains, though ESLs were not available for all isotopes. The ecological SRE indicates potential for risk to ecological receptors from Ra-226, aluminum, barium, selenium, and vanadium (Appendix G, Table G-4 for radionuclides and Table G-5 for metals). Concentrations of aluminum, barium and vanadium were below background levels (Appendix G, Table G-5); therefore, these three metals were not considered to be chemicals of potential ecological concern (COPEC). The maximum concentrations of Ra-226 exceeded receptor-specific ecological screening levels for soil invertebrates and birds (Appendix G, Table G-4); maximum concentration of selenium exceeded receptor-specific ecological screening levels for plants, soil invertebrates, birds and mammals (Appendix G, Table G-5).

A SLERA uses conservative screening-level assumptions such as 100% site use, 100% bioavailability, 100% diet consisting of the most contaminated dietary media, and no-effect toxicity data to evaluate risk to populations of upper level organisms. Under more realistic site use conditions, the potential risk to individual organisms would be reduced. The representative average soil concentration and low-effect ecological screening values were used to refine these risk estimates. The average surface soil concentration of Ra-226 exceeds the low effect ecological screening levels for soil invertebrates (Appendix G, Table G-5). Selenium was detected in one of eight samples at a concentration exceeding low-effect ecological screening levels for plants, avian herbivores, insectivores and carnivores, and mammalian herbivores and insectivores.

The location where the detected selenium was measured is co-located with locations of elevated Ra-226; the sample was collected near the mine waste piles in Section 33. Selenium is a common metal in association with uranium in the Grants Mineral Belt deposits (Brookins, 1982). As an impurity, it may have been a waste metal in the uranium mine waste. ESLs for radionuclides are higher (less stringent) than the proposed action level for protection of human health. Thus, it is anticipated that site actions to address radionuclide exposure by human receptors will be protective for exposure of ecological receptors to both radionuclides and non-radionuclide chemicals.

# 1.5.4 Evaluation of Grazing of Forage by Domesticated Animals and Wildlife

EPA collected eight vegetative metals uptake samples in order to determine the current vegetative nutrient values and uptake of potentially hazardous constituents available to grazing animals (domesticated animals and wildlife). Tissue samples were analyzed for nutrients (iron, zinc, copper, and manganese) and for toxic metals (molybdenum, uranium, vanadium, and selenium). Surface vegetation samples were collected from the eight vegetation transects identified during the Natural Resources Evaluation (NV5, 2019a), which included three transects in the Great Basin Desert Scrub community type (dominated by four-wing saltbush/kochia/gumweed/various weeds), two transects in the Great Basin Desert Scrub community type (dominated by four-wing saltbush/blue grama/galleta/western wheat grass), one transect in the Coniferous Woodland community type (dominated by one-seed juniper/pinyon pine/Bigelow sage) and two transects from the Arroyo Riparian community type (dominated by rabbitbrush/saltbush/galleta).

The results of the evaluation of the vegetative metals uptake samples are included in Appendix G, Table G-7, and sample locations are illustrated on Figure 1-17. Tissue concentrations were compared to maximum tolerable limits (MTLs) developed by the National Research Council's Committee on Minerals and Toxic Substances in Diets and Water for Animals (National Research Council, 2005). The MTL is defined as "the dietary level that, when fed for a defined period of time, will not impair animal health or performance." Tissue concentrations are also compared to concentrations of trace elements in mature leaf tissue that are considered sufficient or normal and excessive or toxic (Kabata-Pendias and Pendias, 1992). With the exception of iron, nutrient (zinc, copper, and manganese) concentrations are less than MTLs for animals and within or less than sufficient/normal concentrations for plants (Appendix G, Table G-7). The iron concentration in four of eight samples exceed the MTLs for all listed mammals except swine. Iron is an essential

nutrient; iron toxicity is dependent on absorption (NRC, 2005). Tissue samples for selenium and uranium (toxic metals) do not exceed thresholds. The vanadium concentrations do not exceed the MTLs for animals, but two of eight tissue samples fall within the excessive/toxic level for plants. Vanadium is commonly associated with uranium in the GMB deposits (Brookins, 1982); concentrations measured in soil were less than regional background. The molybdenum concentration in one of eight samples exceeds the MTL for rodents, horse, cattle, and sheep. Molybdenum toxicity is often associated with inadequate available copper; cattle show overt toxicosis when dietary molybdenum levels are at 100 mg/kg or higher regardless of dietary copper or sulfur levels (NRC, 2005). No molybdenum concentrations in tissue exceed 100 mg/kg. The molybdenum concentration in one tissue sample falls between the range of sufficient/normal levels and excessive/toxic levels for plants.

## 2.0 REMOVAL ACTION OBJECTIVES

The first step in developing removal alternatives is to establish RAOs. These objectives are typically based on COPCs, ARARs, and the findings of the human health and ecological streamlined risk evaluations. General response actions are then developed to describe measures that will satisfy the RAOs. This includes estimating the areas or volumes to which the response actions may be applied.

The main objective of this removal action is to mitigate the actual or potential risks to human health and/or the environment posed by the excess radiological on-site contamination, and to the extent feasible, reclaim the entire Site for the expected future land use for unrestricted residential. Removal action alternatives will address mine wastes and surface and subsurface soils/debris that were contaminated by mine wastes as part of mine operations.

As stated in Section 1.5.2, there are currently several residences located in Section 32, while Section 33 is used for livestock grazing. It is reasonable to assume that both land uses will continue in their respective geographic sections in the future. From a risk perspective, an assumption of residential land use is more conservative (i.e., more protective of human health) than an assumption of non-residential cattle ranching; consequently, a residential future land use is assumed for the Site.

#### 2.1 STATUTORY LIMIT

Pursuant to Section 104(c)(1), CERCLA places statutory limits of 2 million dollars and 12 months on Fund-financed removal actions. The statutory limits do not apply to this action since the selected action will be funded by proceeds of a settlement from an enforcement action and not by the Fund.

#### 2.2 REMOVAL ACTION SCOPE

The scope of the response action will be to address excess radiological contamination in surface and subsurface soils/debris and is intended to be the final action for the soils at the Site. Options to be analyzed include response actions that would allow unrestricted/uncontrolled residential use. Characterization of the Site identified the primary environmental concern to be radiological contamination.

#### 2.2.1 Action Level

Q&A (EPA, 2014). According to this guidance, risks from radionuclide exposures at CERCLA sites should be estimated in a manner analogous to that used for chemical contaminants. The estimates of intake values for parameters associated with Site-specific routes of exposure estimated for the land use should be coupled with the appropriate slope factors for each radionuclide and exposure pathway. The guidance further recommends the use of EPA's on-line PRG Calculator for this assessment. When calculating radiological cleanup levels, the total incremental lifetime

cancer risk attributed to radiation exposure is estimated as the sum of the risks from all

radionuclides in all exposure pathways. Accordingly, the EPA used the PRG Calculator and

coordinated with the national radiation subject matter specialist in EPA's Office of Superfund

Remediation and Technology Innovation to calculate a site-specific soil DCGL.

In June 2014, EPA issued OSWER 9285.6-20, Radiation Risk Assessment at CERCLA Sites:

The DCGL is a term referenced in MARSSIM, a document prepared collaboratively by four federal agencies having authority and control over radioactive materials: EPA, Nuclear Regulatory Commission (NRC), Department of Energy (DOE), and Department of Defense (DOD). The MARSSIM, published in 2000, provides a nationally consistent consensus approach to conducting radiation surveys and investigations at potentially contaminated sites. In addition to planning, conducting, and assessing radiological surveys of surface soils and building surfaces, the document provides a decision-making process to determine if site conditions are in compliance with dose-based or risk-based regulatory criteria. As defined by the MARSSIM, the DCGL is a radionuclide-specific soil concentration determined through pathway modeling that would result in a risk equal to the release criterion above background. EPA used a cancer morbidity risk of 1x10<sup>-4</sup> as the release criterion *above*, or *exclusive* of, background.

A Conceptual Site Model (CSM), provided as Table 2-1, was created to develop the DCGL. The CSM outlines the primary source of contamination, the release mechanism, the receiving media, the transport process, the exposure media and point, and the exposure route for the Navajo tribal lifeway and the general public. As seen in Table 2-1, across all exposure points, four exposure pathways were considered to develop the DCGL: (1) incidental ingestion of surface soil; (2) inhalation of surface soil particulates; (3) external exposure to gamma radiation in soil; and (4) ingestion of livestock meats. Two additional exposure pathways, contaminant migration to

groundwater and indoor radon inhalation, do exist potentially at the Site, but are outside the scope of this EE/CA. The risk of groundwater contamination will be addressed by the EPA Region 6 Remedial Branch as part of a San Mateo Creek Basin groundwater investigation and the risk of indoor inhalation of radon will be addressed using the methodology outlined in the report *EPA Assessment of Risks from Radon in Homes* (EPA, 2003). Proposed actions in this EE/CA (see Section 3) are, however, consistent with and will contribute to any contemplated future remedial actions regarding groundwater and radon through source control by greatly reducing or eliminating the potential for contaminants to migrate from the surface/ subsurface to groundwater and indoor atmospheres.

Given the above exposure pathways for residential land use, three land-use scenarios were considered to develop the DCGL: 75-year lifetime exposure including livestock meat ingestion, 75-year lifetime exposure *excluding* livestock meat ingestion, and 26-year lifetime exposure *excluding* livestock meat ingestion. Table 2-2 displays the risks of the BTV, DCGL, and the modeled action level (sum of the BTV and the DCGL) as compared to the action level in units of risk (acceptable target risk) for the three scenarios. The maximum acceptable target risk of  $3x10^{-4}$  was established via communication with EPA's national radiation expert in the Office of Superfund Remediation and Technology Innovation (OSRTI). The PRG Calculator-produced outputs for the three scenarios are provided in Appendix H.

With the exception of lifetime exposure duration, PRG Calculator default values were used for the remaining exposure parameter values except for the particulate emission factor (PEF) that is used to calculate the risk from the inhalation of soil particulates exposure pathway. In this instance, the city of Albuquerque was chosen for the climatic zone parameter to determine the PEF. PRG Calculator default values were derived by EPA to represent reasonable maximum exposure to broad-based populations, typically 90 to 95 percentile values, which are well above the mean. PRG Calculator input values for the three scenarios are provided as part of the PRG Calculator-produced outputs in Appendix H.

The radiological COCs include the entire uranium-238 (U-238) decay chain up to, and including, thallium-206 (Tl-206), of which Ra-226 is a member, and the entire uranium-235 (U-235) decay chain up to, and including, thallium-207 (Tl-207). It is assumed the U-238 and U-235 decay chains

exist in secular equilibrium and that the U-235 concentration is 2% of the total uranium (U-238, U-235, and U-234) concentration (Argonne National Laboratory, 2007).

Table 2-2
Comparisons of Background, DCGL, and Action Level Risks to Target Risk
Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site
McKinley County, New Mexico

	Background		DCGL		Action Level		
¹Scenario	BTV UTL-95-95 (pCi/g Ra-226)	<sup>2</sup> BTV UTL95-95 Risk	³DCGL (pCi/g Ra-226)	³DCGL Risk	<sup>3</sup> Modeled Action Level (Bkgd UTL95-95 + DCGL) (pCi/g Ra-226)	<sup>3</sup> Modeled Action Level Risk	<sup>2</sup> Action Level (Acceptable Target Risk)
Residential -							
75 Years							
(Includes							
Livestock							
Meat)	1.54	6.5x10 <sup>-4</sup>	0.155	1x10 <sup>-4</sup>	1.7	7.5x10 <sup>-4</sup>	3 x 10 <sup>-4</sup>
Residential -							
75 Years							
(Excludes							
Livestock							
Meat)	1.54	3.6x10 <sup>-4</sup>	0.431	1x10 <sup>-4</sup>	2.0	4.6x10 <sup>-4</sup>	3 x 10 <sup>-4</sup>
Residential -							
26 Years	1.54	1.3x10 <sup>-4</sup>			3.0	2.3x10 <sup>-4</sup>	
(Excludes							
Livestock	2.5 (Section				4.0 (Section 33		
Meat)	33 NORM)	1.9x10 <sup>-4</sup>	1.43	1x10 <sup>-4</sup>	NORM area)	2.9x10 <sup>-4</sup>	3 x 10 <sup>-4</sup>

<sup>&</sup>lt;sup>1</sup>Years represent lifetime exposure, including 6 years as child and the remainder as an adult.

## 75-year Lifetime Exposure Including Livestock Meat Ingestion

The PRG Calculator default value for lifetime residential exposure is 26 years, including 6 years as a child and 20 years as an adult. The Navajo Nation government, however, leases Navajo allotment lands to eligible Navajo for residential purposes for 75 years. Additionally, the PRG Calculator residential land-use template excludes the ingestion of livestock meats as an exposure pathway; however, it is included in the farmer land-use template. Thus, using the farmer land-use template, substituting 75 years (6 years as a child and 69 years as an adult) for lifetime residential exposure; including ingestion of livestock meats (beef), incidental ingestion of soil, and inhalation of soil particulates; and excluding exposure to crops (due to the generally arid conditions of the

<sup>&</sup>lt;sup>2</sup>Red bold denotes Action Level (final column) is below background (3rd column) in units of risk.

<sup>&</sup>lt;sup>3</sup>Blue denotes that under this scenario, since the ACTION LEVEL (final column) is less than background (3rd column), the DCGL is non-applicable, but is presented here along with the modeled action level and their associated risks for informational purposes.

Site and observations of current residential activity); the risk of the BTV equals  $6.5 \times 10^{-4}$  and rounds to  $7 \times 10^{-4}$ , which is greater than the maximum target acceptable risk for the Site of  $3 \times 10^{-4}$ . Action levels are not established typically at concentrations below background levels (EPA, 2002). Further, if the action level is established *at* the BTV, then human health risks would remain above EPA's target health goals after cleanup.

## 75-year Lifetime Exposure Excluding Livestock Meat Ingestion

Given that the risk of the BTV under the preceding scenario is greater than the acceptable Site risk, the DCGL was then modeled using the 75-year lifetime exposure and the same exposure pathways, *minus* livestock meat ingestion. Under this scenario, as seen in Table 2-2, the risk of the BTV equals  $3.6 \times 10^{-4}$  and rounds to  $4 \times 10^{-4}$ , which remains greater than the maximum target acceptable risk for the Site of  $3 \times 10^{-4}$ . Again, action levels are not established typically at concentrations below background levels and, further, if the action level is established *at* the BTV, then human health risks would remain above EPA's target health goals after cleanup.

# 26-year Lifetime Exposure Excluding Livestock Meat Ingestion

Given that the risks of the BTV under the two preceding scenarios are greater than the acceptable Site risk, the DCGL was then modeled using the same exposure pathways as the second scenario above but with a 26-year lifetime residential exposure. As stated previously, a 26-year lifetime exposure is the default lifetime exposure duration for the residential template used by the PRG Calculator. Under this scenario, as seen in Table 2-2, the risk of the BTV equals  $1.3 \times 10^{-4}$  and rounds to  $1 \times 10^{-4}$ , which is less than the maximum target acceptable risk for the Site of  $3 \times 10^{-4}$ . Note that the higher background value of 2.5 pCi/g of Ra-226 applied in the NORM-affected area of Section 33, as described in section 1.4.2.2, represents a risk of approximately  $1.9 \times 10^{-4}$  and is thus also less than the maximum target acceptable risk. Therefore, this residential land-use scenario was used to establish a modeled action level.

As presented in Table 2-2, the action level established for the Site for a residential land-use scenario is 3.0 pCi/g for Ra-226, reflecting a PRG Calculator-derived DCGL of 1.43 pCi/g above the Ra-226 BTV of 1.54 pCi/g (Appendix H). For the NORM-affected area of Section 33 with an applied background value of 2.5 pCi/g of Ra-226, the action level equals 4.0 pCi/g for Ra-226.

Although the cumulative PRG Calculator DCGL result of 1.43 pCi/g represents the concentration of each radioisotope in the U-238 decay chain, which together represent a cancer morbidity risk of 1 in 10,000 persons (commonly referred to as a 1x10<sup>-4</sup> risk), the action level is established for Ra-226 because, (a) Ra-226 was found to be a significant contributor of radiological risk to human health (89% [Ra-226 plus short-lived daughter progeny through polonium-214]; see Appendix H for calculation), (b) the U-238 decay chain is in equilibrium, with analysis of Ra-226 (or specifically, its short-lived daughter radioisotope bismuth-214 [Bi-214]) which provides a cost effective method to determine the equilibrium concentration due to Bi-214's readily identifiable gamma ray energy signature via gamma spectroscopy, (c) a cleanup standard is provided in the State of New Mexico's *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico* (NMEMNRD et al, 2016), and (d) Ra-226 is the radionuclide for which historical cleanup limits have been specified. Note that when addressing contamination associated with Ra-226, contamination associated with the full U-238 and U-235 decay chains will also be addressed, as they are co-located with Ra-226.

An action level of 3.0 pCi/g represents a cancer risk of 2.3x10<sup>-4</sup>, inclusive of background conditions. The action level of 4.0 pCi/g for the NORM-affected area of Section 33 represents a cancer risk of 2.9x10<sup>-4</sup>, inclusive of background conditions. These risk-based action levels are proposed for the following reasons:

- They are within the risk range (10<sup>-6</sup> to 10<sup>-4</sup> overall excess cancer risks) cited in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300.430(e) (2)(I)).
- They are distinguishable from background and therefore measurable in the field.
- They are above the analytical detection limit.
- They meet the standard (5.0 pCi/g Ra-226, averaged over the first 15 centimeters of soil below the surface, averaged over any area of 100 square meters) set forth in the State of New Mexico's *Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico* (NMEMNRD, March 2016).

Under a residential land-use scenario outlined above in the third scenario and at the low end of the range within which EPA manages risk (1x10<sup>-6</sup>), a PRG Calculator-derived DCGL for Ra-226 equals 0.01 pCi/g. This concentration is below the analytical detection limit of 0.1 pCi/g for Ra-226.

As surface soil contamination was measured during the RSE in part via gamma scanning, a scanning-equivalent DCGL in cpm was calculated by the following analysis. Using Microshield® gamma ray shielding and dose assessment software (Microshield version 6.02 [Grove, 2008]), the exposure rate above an infinite plane of Ra-226 at 1.0 pCi/g was calculated to be 1.93 μR/hr. From communication with the instrument manufacturer, the response factor for a 3-inch-by-3-inch NaI detector exposed to Ra-226 is 2,150 cpm/μR/hr. Given a DCGL of 1.43 pCi/g, a 3-inch-by-3-inch NaI gamma detector would have a reading of 5,946 cpm above background. Adding this value to the BTV in cpm of 33,612 and the NORM-affected background level of 39,762 cpm, equivalent action levels of 39,558 and 45,733 were calculated to correlate to the action levels of 3.0 and 4.0 pCi/g of Ra-226, respectively.

## 2.2.1.1 RESRAD Calculator

The OSWER 9285.6-20 guidance document states that although EPA recommends using the PRG Calculator to model radionuclide risk to ensure consistency with CERCLA, the NCP and EPA's Superfund guidance for remedial sites, an alternative model may be used if justification is developed (EPA, 2014). Justification should include the model runs using both the recommended EPA PRG Calculator and the alternative model. Pursuant to this goal as an independent check of PRG Calculator results, EPA reviewed several available modeling programs to determine an appropriate alternative model. While none of the models reviewed provided a direct excess risk value, all of the available models would calculate an excess dose value that could be converted to a comparable excess risk value. EPA elected to also model excess radiological risk (converted from excess dose) and calculated a soil action level for this Site using the RESRAD On-Site 7.2 software developed by Argonne National Laboratory. The RESRAD model is well established and is generally viewed as the default model in the Health Physics community. PRG Calculator input values, including default values, for all parameters across the four exposure pathways noted previously as well as the U-238 and U-235 decay-chain contaminants of concern were replicated in RESRAD to the maximum extent possible to comport with OSWER 9285.6-20 guidance. The same four exposure pathways considered in the PRG Calculator, described in the preceding subsection, were duplicated in RESRAD.

The RESRAD model-derived DCGL of 1.2 pCi/g Ra-226, when added to the BTV of 1.5 pCi/g, results in an action level of 2.7 pCi/g for Ra-226. The action level for the Section 33 NORM area

equals 3.7 pCi/g of Ra-226. EPA determined that the action level derived by the PRG Calculator was appropriate and valid for this Site since the PRG Calculator was designed by EPA for the specific needs of the agency for the calculation of excess radiological risk. The RESRAD output is provided in Appendix H for reference and comparison to the PRG output.

# 2.2.2 Principal Threat Waste Level

The EPA *Guidance on Principal Threat and Low Level Threat Waste* recommends treatment of principal threat waste when practicable (EPA, 1991a). The guidance aligns with, and supports, the NCP, promulgated on March 8, 1990, which states that EPA expects to use 'treatment to address the principal threats posed by a site, wherever practicable (40 CFR Section 300.430(a)(1)(iii)). The expectation is derived from the mandates of CERCLA § 121 and the guidance was developed to communicate the types of remedies that the EPA generally anticipates to find appropriate for specific types of wastes. It reflects EPA's belief that certain source materials are addressed best through treatment because of technical limitations to the long-term reliability of containment technologies or the serious consequences of exposure should a release occur.

The concept of principal threat waste and low-level threat waste as developed by EPA in the NCP is to be applied on a site-specific basis when characterizing source material. Source material is defined as that which includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, to surface water or air, or acts as a source for direct exposure. Examples of source materials include drummed wastes, contaminated soil and debris, "pools" of dense non-aqueous phase liquids (NAPLs) submerged beneath groundwater or in fractured bedrock, NAPLs floating on groundwater, and contaminated sediments and sludges. Principal threat wastes are in turn those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds. No "threshold level" of toxicity/risk has been established to equate to "principal threat"; however, where toxicity and mobility of source material combine to pose a potential risk of 10<sup>-3</sup> or greater, generally, treatment alternatives should be evaluated. In summary, determinations as to whether a source material is a principal or low-level threat waste should be based on the inherent toxicity as well as consideration of the physical state of the material, the potential mobility of the wastes in the particular environmental setting, and the lability and degradation products of the material.

These determinations serve as general guidelines and do not dictate the selection of a particular remedial alternative. In fact, the preamble to the NCP (55 FR at 8703, March 8, 1990) states that there may be situations where wastes identified as constituting a principal threat may be contained rather than treated due to difficulties in treating the wastes. Specific situations that may limit the use of treatment include:

- Treatment technologies are not technically feasible or are not available within a reasonable time frame;
- The extraordinary volume of materials or complexity of the site make implementation of treatment technologies impractical;
- Implementation of a treatment-based remedy would result in greater overall risk to human health and the environment due to risks posed to workers or the surrounding community during implementation; or
- Severe effects across environmental media resulting from implementation would occur.

Aside from the expectation that treatment would be used to address principal threat waste when practicable, the selection of an appropriate waste management strategy is determined solely through the remedy selection process outlined in the NCP (i.e., all remedy selection decisions are site-specific and must be based on a comparative analysis of the alternatives using the nine criteria in accordance with the NCP). Independent of the expectation, selected remedies must be protective, ARAR-compliant, cost-effective, and use permanent solutions or treatment to the maximum extent practicable.

For the Sections 32 and 33 Mines Site, Ra-226 is not characterized as a *principal threat waste* based on the following analysis of RSE data and all the guidance document criteria.

- There exists an area of approximately 4 acres where the highest Ra-226 concentration equals approximately 53 pCi/g, representing an excess cancer-incidence risk, inclusive of background, of approximately 1x10<sup>-3</sup>. However, as discussed above, toxicity is not the sole determining factor in defining a waste material as a principal threat waste. In particular, mobility of the waste should be considered.
- There exists no highly toxic or highly mobile wastes at the Site. Specifically, there exists no threat of contaminant migration to ground or surface water at the Site.

- Contaminant mobility to air or direct exposure to the contaminant has been nullified effectively and reliably through containment technologies at numerous DOE sites with similar contaminants, specifically through repository cells with engineered caps.
- There is not a feasible treatment method for Ra-226 in soil (see Section 3.1).

For these reasons, based on the RSE data for the Site, EPA has determined that Ra-226 does not meet the criteria established in the guidance document referenced above for a *principal threat* waste on this Site.

#### 2.3 SURFACE AREA AND VOLUME ESTIMATE OF CONTAMINATED MEDIA

The lateral and vertical extent of areas exceeding the action level were determined via gamma scanning and soil sampling, respectively, then plotting the results geographically using ESRI's ArcGIS ArcMap version 10.3. The lateral and vertical extent of contamination that requires corrective action is based on comparisons to the action level, (sums of 39,558 cpm and 45,734 cpm [Section 33 NORM area][lateral extent] and 3.0 pCi/g and 4.0 pCi/g [Section 33 NORM area] of Ra-226[vertical extent]). EPA employed the Inverse Distance Weighted (IDW) interpolation method to demarcate the areal extent of vertical contamination above the action level, given the nature of soil sampling providing less than 100 percent assessment coverage.

The total surface area exceeding the scanning-equivalent action level was established to be 949,483 square feet or 22 acres. As discussed in Section 1.4.2.2, the elevated readings east of the mine in Section 33 are considered to be NORM and will not be addressed in this EE/CA. Based on soil samples collected from the contaminated area (Section 1.4.2.3), the soil will need to be excavated to a depth of 2 feet. Additionally, approximately 34,686 cubic yards (CY) of material had been placed into a temporary stockpile during the 2014 removal action by EPA Region 9. The total volume of soil exceeding the action level was determined to be 108,776 CY. The areal extent of contamination and the associated removal-volumetric calculations are illustrated in Figure 2-1.

Table 2-3
Removal Volume Estimates
Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site
McKinley County, New Mexico

	Surface A	Volume		
Zone	Square Feet	Acres	Cubic Yards	
2 ft. Depth	817,455	18.8	60,552	
Stockpile Footprint	121,840	2.8	48,224	
TOTAL	939,295	21.6	108,776	

#### 2.4 REMOVAL ACTION SCHEDULE

The NCP requires a public comment period of at least 30 days following release of the EE/CA report by the EPA (40 CFR 300.415(n)(4)(iii)). The EPA will respond to significant comments received during the public comment period and will publish an Action Memorandum following the response to comments. The Action Memorandum will address the threat to public health and the environment posed by the Site. The EPA will begin removal operations within 6 to 9 months of the signed memorandum. The removal start date will be contingent on multiple factors including weather, contract approval, and funding availability. The EPA will provide public notification of the schedule for this process upon issuance of the Action Memorandum.

## 3.0 REMOVAL ACTION ALTERNATIVES

EPA guidance for preparing EE/CAs suggests identifying and assessing a limited number of alternatives appropriate for addressing the RAOs (EPA, 1993). Removal technologies applicable to each alternative are identified and discussed with respect to their effectiveness and implementability. Technologies that were initially considered but were screened as infeasible for technical reasons are presented and discussed in Section 3.1 and a discussion of ARARs is provided in Section 3.2. The applicable technologies are then assembled into removal alternatives in Sections 3.4 through 3.8. Based on knowledge and experience with removal actions at similar sites, the following three removal action alternatives were evaluated for the Sections 32 and 33 Mines Site:

Alternative 1: No Further Action

Alternative 2: Excavation and Off-Site Disposal of Contaminated Soils at a Licensed

Low-Level Radioactive Waste Facility

Alternative 3: Consolidation and Capping of Contaminated Soils in Place

The alternatives have been developed to mitigate potential threats posed by controlling human exposure to wastes with concentrations of Ra-226 above the action level (Section 2.2.1). These alternatives were also developed based on federal guidance as described in Section 3.2. Sections 4.0 and 5.0 evaluate the alternatives individually and comparatively using the criteria established by the EPA. Figure 2-1 illustrates the excavation areas and presents the volumes of contaminated soil that would be transferred off-site for Alternative 2 or capped in place for Alternative 3. Appendix I Table I-1 summarizes the alternatives, presenting the estimated costs and schedule for each. Several other alternatives were considered but ruled out as not viable, as described below in Section 3.1.

The conceptual design assumptions used for each alternative are discussed in the following sections. As described in Section 2.3, the area and depth estimates used to calculate the removal action volumes were determined through Arc-GIS analysis based on plotting on-site gamma scanning and soil sampling data. As additional site data are obtained, it is anticipated that the volume estimate would be refined. However, the EPA considers the volume estimates summarized

in Figure 2-1 to be sufficiently accurate for the purposes of comparing costs and conceptual designs in this EE/CA.

#### 3.1 ALTERNATIVES SCREENED FROM CONSIDERATION

The process of identifying and evaluating alternatives to meet the RAOs began with an initial screening of alternatives to determine if any were considered to be technically or administratively infeasible. The following alternatives were screened from consideration during this prescreening step:

- Institutional Controls: Implementing security measures to prevent access to the Site was considered as an alternative. Moderate access restrictions are currently in place through barbed wire fencing. This alternative would involve restricting access to the area by use of a more robust physical barrier, such as chain-link fencing, and providing a lockable gate. Although the institutional controls alternative will be effective in reducing exposure to human receptors by increasing distance to the most contaminated areas, it will not restrict exposure of authorized personnel accessing the Site or some ecological receptors (such as reptiles and avian species). It will also not reduce the mobility or volume of contaminated material, where migration potential remains likely due to water and wind effects. Due to these issues with effectiveness, this alternative was screened from further consideration.
- Vegetative Extraction (Phytoremediation): Alternative treatment methods such as phytoremediation (the use of plants to absorb radionuclides and other contaminants) were considered but screened as infeasible for this Site. This alternative would require the planting and irrigation of the full removal area, regular harvesting and disposal of radioactive-contaminated plant material, and access restriction during the treatment period to prevent human exposure to and animal consumption of the plants. It is difficult to predict the effectiveness and timeframe of this option. Due to these implementability and effectiveness issues, this alternative was screened from further consideration.
- Soil Washing: Ex-situ soil washing, a process that uses physical and/or chemical techniques to scrub metals from soil, was considered for this Site. The aqueous-based system can consist solely of water or can be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent (Interstate Technology & Regulatory Council [ITRC], 1997). The process takes advantage of the tendency of the metals to concentrate in silt and clay (Federal Remediation Technologies Roundtable [FRTR], 2014) and separates the fine soil (silt and clay) containing the majority of the COPCs from the coarse soil (sand and gravel). The smaller volume of fine soil can then be disposed of either onsite or off-site, and the clean, coarser soil can be used on-site for various purposes provided it meets the cleanup criteria. There have been only six recorded applications in the United States through 2011 (EPA, 2013). The reasons for this include the need for large volumes

of water, introduction of chemicals into the wash water and possible additional treatment steps to address hazardous levels remaining in the treated residuals, need for disposal or treatment of the radium-enriched wash water, need for specialized equipment, difficulty of containment of water during and after washing, and increased risk of worker exposure. Due to these issues, this alternative was screened from further consideration.

• Soil Sorting: Soil sorting is an ex-situ process that separates soils based upon predetermined radioactivity levels. Soil passes under an array of radiation detectors that are used to determine the radioactivity present. Those portions that exceed pre-determined levels are identified and flagged for mechanical separation from the rest of the soil. Given the relatively low-to-moderate range of radioactivity levels in contaminated soil at the Site, as compared to most NRC, DOE, and DOD facilities; the lack of acceptable on-site alternative uses or potential cost savings for differing disposal options for the variously contaminated soils at the Site; the increased risk of worker safety from increased handling of the contaminated soils; and strong potential for overall cost increases from additional specialized equipment/increased maintenance or repair down time, this option appeared to provide no significant benefit in either protectiveness or cost savings over more conventional alternatives and was therefore screened from further consideration.

# 3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

This EE/CA was developed following the basic methodology outlined in 40 CFR §300.415 and further discussed in the EE/CA Guidance (EPA, 1993). Section 121(d) of CERCLA requires that response actions comply with state and federal ARARs unless a waiver is justified. ARARs are used to assist in determining the appropriate extent of site cleanup, to scope and formulate removal action alternatives, and to govern the implementation of a selected response action (EPA, 1988 and 1989). The following sections provide a definition of ARARs and describe the ARARs that are specific to the Site.

#### 3.2.1 Terms and Definitions

The NCP provides that response actions must attain ARARs to the extent practicable, considering the exigencies of the situation (40 CFR 300.415(j)). As discussed in the EPA *Guidance on the Consideration of ARARs during Removal Actions* (EPA, 1991b), NTCRAs will generally, where practicable, allow for greater compliance with ARARs than time-critical removal actions (TCRAs).

In the course of conducting the EE/CA for the Sections 32 and 33 Mines Site, ARARs as well as other "To Be Considered" (TBC) criteria were identified from policy or guidance documents that may be pertinent to evaluating and implementing removal options. ARARs and TBC criteria are defined as follows:

- Applicable Requirements are cleanup standards, standards of control, and other substantive
  requirements, criteria, or limitations promulgated under federal or state environmental laws
  that specifically address a hazardous substance, pollutant, contaminant, remedial action,
  location, or other circumstance found at a CERCLA site.
- Relevant and Appropriate Requirements are cleanup standards, standards of control, and
  other substantive requirements, criteria, or limitations promulgated under federal or state
  environmental laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address
  problems or situations sufficiently similar to those encountered at the CERCLA site and
  are well-suited to the particular site.
- TBC Criteria consist of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies and include non-promulgated guidance or advisories that are not legally binding and that do not have the status of potential ARARs. TBCs generally fall within three categories: health effects information with a high degree of credibility, technical information on how to perform or evaluate site investigations or response actions, and policy.

The EPA has divided ARARs into three categories: chemical-specific, location-specific, and action-specific. The three categories are described below:

- <u>Chemical-Specific ARARs</u> are usually health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.
- <u>Location-Specific ARARs</u> apply to the geographical or physical location of a site. These requirements limit where and how the removal action can occur.
- <u>Action-Specific ARARs</u> include performance, design, or other controls on the specific activities to be performed as part of the removal action for a site.

ARARs and TBC criteria for the Sections 32 and 33 Mines Site, along with a brief description of each, are provided in Tables 3-1, 3-2, and 3-3, respectively.

# 3.2.2 Other Considerations and Assumptions

The following additional considerations and assumptions were made during the ARAR identification process.

#### 3.2.2.1 Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) has promulgated standards for the protection of workers who may be exposed to hazardous substances at Resource Conservation and Recovery Act (RCRA) or CERCLA sites (29 CFR Parts 1910.120 and 1926.65). The EPA requires compliance with OSHA standards in the NCP (40 CFR 300.150), but not through the ARAR process. Therefore, OSHA standards are not considered ARARs. Since the requirements, standards, and regulations of OSHA are not ARARs and cannot be waived, they will be complied with during the removal action.

# 3.2.2.2 Uranium Mill Tailings Radiation Control Act

The UMTRCA programs are categorized under Title I and Title II. Title I addresses specific inactive uranium processing sites, and Title II addresses active sites that are required to have a license from the NRC. Under UMTRCA, the EPA was directed to devise standards for both the control and cleanup of excess radiation from uranium mill tailings. The mines located in the Sections 32 and 33 Mines Site are not a listed site under Title I of UMTRCA, nor would the wastes be classified under Title II. However, UMTRCA requirements may be TBCs under certain circumstances, as reflected in Table 3-1.

#### 3.2.2.3 Multi-Agency Radiation Survey and Site Investigation Manual

The activities of this removal action shall be conducted in a manner consistent with the MARSSIM (EPA, 2000b) specifications to facilitate implementation of a final status survey at the completion of mitigation activities. The MARSSIM is guidance, not a promulgated standard, and thus is not an ARAR, though it may be applied as TBC.

For the purposes of the final status survey, the DCGL referenced in the MARSSIM will be equivalent to 1.43 pCi/g of Ra-226, a value equivalent to the PRG Calculator result (see section 2.2.1). The DCGL is a radionuclide-specific soil concentration that would result in a risk equal to

the release criterion (i.e., 1.43 pCi/g above background). If radioactivity is relatively evenly distributed over a large area, MARSSIM considers the average concentration over the entire area (termed DCGL<sub>W</sub>; meaning DCGL for a "wide area"). Thus, more specifically, the DCGL<sub>W</sub> will be equivalent to 1.43 pCi/g of Ra-226.

Concentrations greater than the DCGLw are allowed provided that the average concentration over the survey area is less than the DCGLw. The MARSSIM approach allows for calculation of a higher DCGL, for small areas of concentrated radioactivity within the "wide area," based upon "area weighting factors." This value is termed the DCGLemc ('emc' represents the elevated measurement comparison). The DCGLemc is typically a multiple of the DCGLw and will differ depending on the distance between sample points collected during the MARSSIM final status survey (over-arching release criterion prescribed by MARSSIM) in each survey unit. This approach accounts for the fact that the resident will receive a greater dose from a smaller area of contaminated soil than from the more homogenously contaminated 'wide area', but because the DCGLemc is not exceeded, the average dose to a receptor is still in compliance with the release criterion, assuming the survey unit passes an appropriate statistical test. Calculations of DCGLemc values will be calculated post-removal as part of final status surveys.

# 3.3 ENGINEERING AND LOGISTICAL CONCERNS APPLICABLE TO MOST ALTERNATIVES

Alternatives 2 and 3 each require the following common components and activities:

- Plans and specifications
- Planning documents
- Cultural and biological resource surveys
- Mobilization and site setup
- Clearing and grubbing
- Site security and access controls
- Road and haul route improvements
- Road and haul route maintenance
- On-site traffic control

- Air monitoring and dust control
- Stormwater management, erosion control, and maintenance
- Confirmation sampling
- Site reclamation

The costs for these common activities are included in the estimated cost for each alternative (Appendix I).

#### 3.3.1 Plans and Submittals

Prior to mobilization activities, work plans, construction plans, and technical specifications would need to be prepared for Alternatives 2 and 3. Work plans, construction plans, and specifications will consider information presented in the Natural Resources Evaluation Report (Appendix A) and the Cultural Resources Survey Report (Appendix B), as well as recommendations or requirements from the New Mexico SHPO, New Mexico SLO, or tribal consultation.

Required plans would include, at a minimum, a Removal Action Work Plan to include a Health and Safety Plan, Environmental Protection Plan, Quality Assurance Project Plan, Field Sampling/Monitoring Plan, Site Access and Security Plan, Traffic Control Plan, Stormwater Management and Erosion Control Plan, Cultural Resource Protection Plan, Dust Control Plan, Revegetation Plan, and Final Status Survey Plan.

The design process will also require an evaluation of the potential environmental footprint of the project, prepared in accordance with the EPA guidance document *Methodology for Understanding* and Reducing a Project's Environmental Footprint (EPA 2012) and the ASTM International Standard Guide for Greener Cleanups, E2983-16e1 (ASTM 2016).

## 3.3.2 Mobilization and Site Setup

A gamma activity survey in conjunction with soil sampling has been completed to delineate the areas to be excavated. Temporary on-site facilities for project management and project controls would be mobilized to the Site for the duration of the project. Temporary on-site facilities would be constructed for decontamination of personnel and equipment (e.g., tools, salvageable equipment, passenger vehicles, and heavy equipment). Aboveground electrical lines cross the site.

A subsurface utility survey is necessary to identify and/or verify the location of buried utilities. Areas scheduled for utility surveys would include excavation, borrow and transfer areas, heavy equipment traversing paths, areas slated for drainage way improvements, and areas where material may be stockpiled.

To prepare the Site for implementation of Alternatives 2 and 3, the ecological and cultural resource surveys would be reviewed prior to mobilization. If necessary, additional surveys would be performed by EPA-approved biologists or archeologists. Based on the information gathered in the completed survey and for the purposes of this EE/CA, and consistent with other CERCLA actions taken in this area, it is assumed that cultural resources can be avoided or protected during site work activities.

As stated in Section 1.2.10, an Environmental Protection Plan will be developed prior to the initiation of removal activities and will identify sensitive ecological habitats and species documented during the survey. Removal activities may be scheduled to avoid certain critical periods of the year such as nesting or breeding seasons.

#### 3.3.3 Site Security and Access Control

Security would be maintained during all non-working hours while site work is occurring. The Site Manager and the Health and Safety Officer would be responsible for personnel while they are on the Site. To restrict access, the Site would remain completely fenced throughout the duration of construction activities occurring using Alternatives 2 and 3, along with appropriate signage designating potential hazards and contacts to obtain additional information. Temporary fencing would be used whenever the permanent fence must be removed for construction access. Alternate entrances that may be required for portions of the work would be secured when not in use. If work activities are occurring at several locations, then security would need to be maintained at each.

The EPA and its authorized representatives, including its contractors, would have access to the Site at all times. A Site Access and Security Plan would describe the activities used to monitor and control access to the Site during implementation of the response actions using Alternatives 2 and 3 and the periods of work performance.

#### 3.3.4 Road and Haul Route Improvements

Currently, an unimproved network of roads is present that were considered for hauling and transportation. Four optional routes were evaluated to determine the cost of road improvements that would be incurred for Alternatives 2 and 3. Each option would include the appropriate improvements (grading, surfacing, and surface water control) to sustain anticipated activities on the Site including general vehicle access, waste hauling, and heavy equipment movement.

Access roads will be surfaced with appropriately sized gravel to control erosion and provide a stable surface for heavy equipment. Roads would be maintained for the duration of the removal action. Without surfacing, many of the site roads become unusable during precipitation events due to the local soil composition. Additionally, new road culverts could be required at the larger arroyo crossing locations.

Rail transportation is a potential future consideration for Alternative 2 (off-site disposal of the contaminated soils at a licensed low-level radioactive waste facility); however, the cost estimates in this report assumed truck transportation and disposal of the waste materials due to the lack of current rail infrastructure. Table 3-4 is a summary of cost estimates used to evaluate the optional transportation routes.

#### 3.3.5 Road and Haul Route Maintenance

Alternatives 2 and 3 will require an extensive amount of haul traffic both on-site and off-site over the removal action duration to achieve completion. During transportation of heavy equipment and soil hauling, traffic controls are necessary. A traffic control plan will be developed and followed throughout the removal action operations.

Off-road haul routes would be maintained so that dust, debris, or mud are not created, and so that these items are not tracked onto paved surfaces. Earthen haul routes would be shaped or otherwise improved so that they are free draining and would not easily erode. Signs and barriers would be provided, if necessary, to contain traffic along the designated routes.

## 3.3.6 Air Monitoring and Dust Control

As part of the Site Sampling and Analysis Plan, specific methods and procedures would be included for air quality monitoring, collecting, analyzing, and evaluating air samples within and at the perimeter of work zones as described for Alternatives 2 and 3. Prior to commencing dust-generating activities in the contaminated excavation areas, perimeter work zone samples would be collected to establish background alpha and beta activity concentrations in ambient air. The background air samples would be used to establish the COPC activity concentrations that are naturally occurring in the air and unrelated to the removal activities occurring at the Site. Perimeter and work zone air monitoring stations would be positioned and operated to monitor emissions during grubbing, excavation, stockpiling, loading of bulk-carriers, stockpile management, and Site reclamation.

The Dust Control Plan, referenced in Section 3.3.1, will detail how air monitoring results and dust suppression measures would be implemented to document that potential off-site migration of contaminants at unacceptable radiological activity concentrations does not occur; to maintain compliant air quality conditions and a safe working environment; and to protect the health of workers, the general public, and the environment during removal operations using Alternatives 2 and 3. Dust controls would also be used to minimize fugitive dust generated from soil imported from either on-site or off-site borrow sources. Perimeter air monitoring would be performed during earthmoving activities associated with site reclamation. Frequent water or water/tackifier solution spraying would be used during soil moving activities at the Site and during construction and waste placement work at the repository, if selected. Appropriate stop work protocols will be incorporated in the Dust Control Plan for seasonal high wind events when dust suppression using watering or a water/tackifier solution is ineffective.

For costing purposes, it was assumed that water for dust control would be obtained and hauled from Grants, New Mexico, and stored on-site in mobile water tank trailer towers.

## 3.3.7 Stormwater Management, Erosion Control, and Maintenance

As described above, the Site is located in an arid to semi-arid area of New Mexico. While thunderstorms and significant moisture events are generally confined to the monsoon season, significant snow events can occur, along with flash flooding events. Stormwater management and

erosion control are of significant concern based on the size and the extent of the excavation activities associated with Alternatives 2 and 3 of this removal action. As referenced in Section 3.3.1, a Stormwater Management and Erosion Control Plan will be prepared to address stormwater management and erosion control procedures during the duration of the removal activities on this Site.

Excavated areas would be graded and re-contoured to reduce overland and low-energy concentrated flow rates and patterns as per the Carlson Natural Regrade conceptual model discussed in Section 1.4.2.4. The natural regrading design integrates the post removal reclaimed area topography and existing drainage patterns to facilitate the development of a stable land surface for the development of a viable post removal ecosystem. All removal related activities at the Site must be evaluated for potential impacts on federally-listed species and critical habitat for certification to meet the substantive requirements of the Notice of Intent, under the National Pollutant Discharge Elimination System (NPDES) Multi-Sector General Permit. Once the Site has been stabilized, monitoring of construction stormwater runoff would cease and post removal site controls would be initiated. The cost estimates include provisions for ongoing cover maintenance, and fence inspection and repair at the final repository for Alternative 3.

#### 3.3.8 Site Reclamation

Prior to initiation of reclamation activities, topographical and meteorological data for the Site would be entered into the Carlson Natural Regrade modeling software to produce a conceptual plan for reclamation. The plan would strive to return the topography of the Site to pre-mining conditions, which would provide a stable land surface, reduced erosion effects, and a sustainable ecosystem. The plan would also provide strategies for using on-site fill materials to reduce costs associated with importing backfill. The outputs from the plan would be available for review by stakeholders prior to commencement of activities.

Grading where excavation of mine or mine-related waste materials has occurred using Alternatives 2 and 3 would be performed to aid in erosion control (i.e., a slope of 4H:1V or flatter) where erodible soils are present. Re-contouring of the Site would include filling excavations to restore natural drainage conditions. On-site, clean backfill soil may be used for re-contouring the

landscape. The material would be compacted and in-place soil density and moisture testing would be performed to achieve the minimum design relative compaction.

Revegetation of excavated, contaminated areas would be completed to reduce erosion potential while improving grazing suitability and wildlife habitat. Areas to be revegetated will require tilling and soil amendments following re-contouring efforts. As mentioned in Section 1.2.10, revegetation recommendations for the Site were provided in the Natural Resources Evaluation Report (Appendix A).

Vegetation establishment would help to minimize erosion and increase the durability of the cover of the repository. Vegetation should attempt to emulate the local ecological conditions including structure, function, diversity, and dynamics of native plant communities in the area. Diverse mixtures of native and naturalized plants would maximize water efficiency of water usage and remain more resilient given variable and unpredictable changes in the environment resulting from pathogen and pest outbreaks, disturbances (e.g., grazing, fire, etc.), and climatic fluctuations. Therefore, the vegetation plan for the repository cover would include species that are sustainable, once established, under typical climate and resource use patterns.

# 3.4 ALTERNATIVE 1: NO FURTHER ACTION

Under Alternative 1, no new treatment, containment, or removal action would occur at the Site. The No Further Action Alternative has been included as a requirement in Section 300.430(e) of the NCP and to provide a basis for the comparison of the remaining alternatives.

# 3.4.1 Site Work Activities

This alternative would include no new Site work activities. Impacted materials would be left in place. The current site conditions such as slope, surface treatment, and aspect that have been graded would not be modified. Since the current Site conditions do not provide a radon or gamma radiation barrier, future site visitors may be exposed to radiation hazards. The potential for contact with eroded radioactive material or exposure to fugitive dust may also occur due to the lack of stabilization measures.

# 3.4.2 Post-Excavation and Site Reclamation Activities

Since there would be no new work activities at the Site under this alternative, there would be no Site reclamation.

# 3.4.3 Site Controls and Security

The public and livestock are currently restricted access to the Site by barbed wire fencing. However, the fence can be easily damaged or bypassed, presenting a potential exposure to gamma radiation, fugitive dust, and radon emissions for unauthorized personnel and livestock.

#### 3.4.4 Stormwater and Erosion Control

No new stormwater or erosion control activities would be implemented under Alternative 1.

# 3.4.5 Operation and Maintenance Activities

The Site would require annual maintenance to provide the current level of protectiveness from the existing fencing. Existing stormwater and erosion controls would be maintained as necessary.

# 3.5 ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL OF CONTAMINATED SOILS AT A LICENSED LOW-LEVEL RADIOACTIVE WASTE FACILITY

Alternative 2 assumes that contaminated soils with concentrations greater than the action level of 3.0 pCi/g Ra-226 (4.0 pCi/g Ra-226 for Section 33 NORM area) would be excavated and disposed of off-site at a licensed disposal facility permitted to receive the waste.

The three following licensed disposal facilities within the western United States are authorized to accept low-level radioactive waste and/or naturally occurring low-level radioactive soil with Ra-226 concentrations ranging from 2 pCi/g to approximately 500 pCi/g:

- Clean Harbors, Deer Trail, Colorado (550 miles)
- U.S. Ecology, Beatty, Nevada (610 miles)
- U.S. Ecology, Grand View, Idaho (835 miles)

The Clean Harbors facility in Colorado was chosen as the basis of the estimate given its closest proximity to the Site.

Disposal pricing from December 2019 (See Table 3-4) was used to develop the detailed cost estimates included in Appendix I. The estimates assume a disposal fee of \$75.00 per ton at the Clean Harbors Landfill in Deer Trail, Colorado. Transportation costs were estimated separately based on the expected fleet of trucks and transportation distance.

#### 3.5.1 Off-Site Rule

Alternative 2 would require compliance with the Off-Site Rule of CERCLA. In general, the Off-Site Rule requires that facilities that accept contaminated or hazardous wastes from a CERCLA site must be in compliance with all applicable regulations and laws (i.e., they must be approved to take those wastes and be in compliance with the applicable federal, state, and local requirements to do so). A licensed disposal facility for Alternative 2 would have existing approval under the Off-Site Rule.

### 3.5.2 Site Work Activities

The initial site removal work includes clearing and grubbing to remove vegetation and organic debris. Stormwater controls would be implemented during these activities and continued throughout the excavation and backfill process. Contaminated soil would be excavated by a combination of heavy equipment including scrapers, bulldozers, graders, excavators, front-end loaders, and haul trucks. Contaminated soil would be loaded onto haul trucks for transport directly to the final disposal facility.

Transportation by rail or a combination of trucking and rail is an option, but was not considered for the EE/CA since the disposal fee would be a much more significant portion of the total cost. Material would need to be trucked from the Site to a rail line approximately 10 miles south of the site in Prewitt, New Mexico, where a transfer station would need to be established. The material could then be loaded to rail cars and shipped to the selected disposal facility.

Contaminated areas of the Site in Sections 32 and 33 (as shown in Figure 2-1) would be excavated. The on-site excavation and trucking activities are estimated to take approximately 12 months with two loading crews and forty (40) twenty-cubic-yard capacity highway rated haul trucks. Planning and engineering documents are expected to take an additional 8 months before construction mobilization, for a total removal time of 1 year and 8 months to completion.

Waste loading and transportation would occur continuously throughout the course of the removal action. Approximately 7,280 truckloads, assuming 40 trucks per day (20 cubic yards per load for highway legal trucks) for 182 days, would be required to transport the waste material from the Site to the disposal facility. Traffic controls would be in place in order to maintain safe driving conditions due to equipment and vehicles entering and leaving the Site.

The largest equipment that can efficiently be used on the Site that would cause minimal damage to the paved road would be considered. Under this alternative it was assumed that the majority of traffic would use the improved existing site roads and paved highways rated for heavy trucks to move the waste.

### 3.5.3 Post-Excavation and Site Reclamation Activities

Concurrent with the excavation activities, confirmation testing of the bottom and side soils in each excavated area would be conducted to determine the remaining vertical and lateral extent of contamination. Excavation would continue until the action level is met.

Excavated areas would be backfilled with imported or on-site clean soil and graded to restore the existing grade and promote positive drainage. After the waste soil excavation has been backfilled, the area would be reclaimed for livestock grazing and wildlife habitat. Soil amendments would be placed over the backfill area and tilled to promote growth. Revegetation efforts would follow the final Revegetation Plan developed during project planning and modified for final post removal conditions. Progressive revegetation would occur for disturbed and reclaimed areas after completion of removal activities in each removal unit.

# 3.5.4 Site Controls and Security

During the Alternative 2 removal and reclamation activities, Site access would be restricted by a newly installed fence. Domestic livestock would not be allowed to enter the Site until reclaimed. Once vegetation is re-established and the Site has stabilized, perimeter fencing may be removed. Reclamation activities may take 5 years or more before adequate vegetation is re-established in place and final stabilization is achieved.

#### 3.5.5 Stormwater and Erosion Control

Stormwater management and erosion control are of significant concern based on the size and the extent of the excavation activities associated with Alternative 2. As referenced in Section 3.3.1 and 3.3.7 above, a Stormwater Management and Erosion Control Plan would be prepared to address stormwater management and erosion control procedures during the duration of the removal activities on this Site. Modeling using Carlson Natural Regrade would be conducted to develop a reclamation plan that would return the Site to a sustainable topography with natural features to reduce the risk of erosion.

Excavated areas would be graded and re-contoured to reduce overland and low-energy concentrated flow rates and patterns as per the Carlson Natural Regrade conceptual model. The natural regrading design integrates the post-removal reclaimed area topography and existing drainage patterns to facilitate the development of a stable land surface for the development of a viable post removal ecosystem. All removal related activities at the Site must be evaluated for potential impacts on federally-listed species and critical habitat for certification to meet the substantive requirements of the Notice of Intent, under the NPDES Multi-Sector General Permit. Once the Site has been stabilized, monitoring of construction stormwater runoff would cease and post removal site controls would be initiated.

Re-contouring of the Site would include filling excavations to restore natural drainage conditions. On-site, clean backfill soil may be used for re-contouring the landscape. The material would be compacted and in-place soil density and moisture testing would be performed a minimum of 85 percent relative compaction at optimum moisture content (determined by Standard Proctor – ASTM D698) is achieved. Revegetation and reclamation activities described above would further contribute to stormwater and erosion control once the removal action is complete.

# 3.5.6 Operation and Maintenance Activities

Operation and maintenance of the Site during the removal and reclamation activities would be the responsibility of the EPA. After completion of reclamation activities, operations and maintenance (O&M) would be arranged through the Tronox trust fund. The O&M activities would include inspection and maintenance of stormwater and erosion control features for perpetuity. Monitoring

and maintenance of revegetation efforts would occur for an estimated 12 years following revegetation.

# 3.6 ALTERNATIVE 3: CONSOLIDATION AND CAPPING OF CONTAMINATED SOILS IN PLACE

In Alternative 3, contaminated mine and mine-related wastes greater than the action level of 3.0 pCi/g Ra-226 (4.0 pCi/g Ra-226 for Section 33 NORM area) would be consolidated and capped in place at the Site. The capped area would expand the footprint of the existing Section 32 stockpile across the section line to include the footprint of the existing stockpile on Section 33; the final onsite, capped area would be on both sections. Contaminated soil outside of the existing stockpiles would be incorporated into the final cap footprint. The cap height would be designed to be as low as possible and to appear as a natural feature, to the extent practicable. This alternative would involve excavating clean material on-site or importing the material from another location for use in constructing the cap. This alternative envisions a future land-use of residences on the Site, including the capped area, which would require cap thickness(es) able to attenuate the radiological risk emanating from all residential routes of exposure (i.e., direct external gamma, inhalation of soil particulates, and incidental ingestion of soil). Varying surface and subsurface Ra-226 concentrations across the Site would require the development of statistical units for which varying cap thicknesses would be calculated, based on an appropriate Ra-226 concentration (e.g. the 95UCL mean or the maximum single-point concentration) and subsequent risk modeling with the PRG Calculator. Alternatively, an 'over-design,' one-size cap thickness can be considered for the entire Site, calculated to attenuate the risk from a ranching scenario using the appropriate Ra-226 concentration of the most elevated statistical unit. For the purposes of comparing remedial alternatives in this EE/CA, the latter cap-design approach was used and a radiation protection layer (radon barrier) thickness of 30 centimeters (approximately 1 foot) was calculated to attenuate the risk of a Ra-226 concentration of 52.7 pCi/g for a ranching scenario. Given the need for an additional 18-inch infiltration layer and a 6-inch erosion control layer per New Mexico solid waste regulations for landfills (Title 20, Chapter 9, New Mexico Administrative Code), used here as a TBC, a final cap thickness of 3 feet was used. To cover nearly 6 acres with a 3-foot cover, approximately 27,000 CY of cover material would be required.

Several small isolated areas of contamination not contiguous with the larger cleanup area, as well as any potential arroyos and drainage paths, would require excavation and placement of the contaminated material within the area to be capped. A detailed study will have to be undertaken to determine how removal of contaminated material within arroyos will affect drainage patterns in the area. The effects of scour along arroyo bottoms and sidewalls will also have to be evaluated to determine if additional fill material will need to be placed in areas of prior excavation to reestablish a stable hydraulic system and reduce erosion potential.

# 3.6.1 Engineering Design

Alternative 3 uses an engineered cover (cap) as part of the remedial solution. The conceptual model used for the consolidation and cap-in-place option included in the cost analysis for this alternative is described below. The figures in Appendix K illustrate the conceptual 6-acre capping plan.

Several critical factors were considered in designing a cover. These design elements are discussed briefly below and assumptions are made in order to prepare the cost analysis for the alternative. These assumptions may change upon further investigation of the Site. Ultimately the containment design would be based on comprehensive planning and site-specific risk analysis.

- Longevity of the Cover The engineered cover would be designed to be effective for up to 1,000 years to the extent reasonably achievable, but at a minimum for 200 years; this lifespan is highly dependent upon continuing maintenance of the cover and would require long-term monitoring. The net present value (NPV) for the long-term inspections and maintenance of the cover for 100 years is included in the cost estimate.
- Protection from All Routes of Exposure for a Residential Scenario The final cap thickness for Alternative 3 would be determined based on risk modeling of a residential scenario via the PRG Calculator and New Mexico solid waste regulations. Preliminary calculations were performed for this report, which resulted in a cap layer thickness of 3 feet (Appendix K).
- Water Infiltration The cover must protect the contaminated soils and reduce leachate development by minimizing the infiltration of water from precipitation. The cover design would incorporate drainage features and use evapotranspiration to limit water infiltration.
- **Erosion Control** Cap shaping, sloping, and proper drainage patterns are also important to ensure stability of the final consolidated material. The current area has had problems with erosion of cover soils. For this reason, the cost estimates presented for this alternative uses a maximum 20H:1V slope ratio and incorporate drainage features. Water diversion,

velocity breaks, rock intermixed with the surface layer, and placement of rip rap or other protective lining in concentrated flow areas are expected to be the most effective surficial erosion mitigation measures. The capped area is positioned at a sufficient distance from any surface water features to be protective of surface waters. Similarly, information obtained during the ecological and cultural resource surveys would be considered in the design of the final capped footprint. In addition to studying the area being capped, the borrow area where fill material will be taken for the cap would have to be designed to control drainage patterns and erosion due to stormwater events.

• Cover Design – The cost estimate assumes a 24-inch evapotranspiration cover design atop a 30-centimeter (or approximately 1-foot) thick radiological risk-attenuating cover. The evapotranspiration cover is comprised of an 18-inch native soil infiltration layer or borrow material and overlain by a 6-inch thick top soil layer composed of both rock and organic material to promote revegetation and control erosion.

Although the final design may vary, the major cost factors—thickness of cover and source of material—would likely not be significantly different from the cost estimate assumptions. Final design parameters for the capped area would be determined by EPA in consultation with the State of New Mexico and other key stakeholders, as necessary.

# 3.6.2 Site Work Activities

The initial Site removal and consolidation work includes clearing and grubbing and removal of organic debris. Stormwater controls would be implemented during these activities and continued throughout the excavation and site restoration process. Contaminated soil outside of the cap-in-place footprint would be excavated by a combination of heavy mining equipment including scrapers, bulldozers, graders, excavators, front-end loaders, and haul trucks. Contaminated soil would be loaded onto haul trucks at the Site for transport directly to the consolidation area.

During the course of the removal action, it is estimated that approximately 6,664 truckloads (assuming four 34 CY capacity off-road haul trucks working 49 days) would be required to transport waste material from the excavation sites to the consolidated capped area. The largest equipment that can reasonably be used on-site, with relatively quick travel times, and that would cause minimal damage to access routes, should be considered to maximize efficiency. Under this alternative, the majority of traffic would use the existing and upgraded section roads to move the waste to the proposed capped area. The preferred route would be developed in consultation with Navajo Nation and private landowners during the design phase.

The duration for planning, design, and construction is expected to be 2 years. The on-site excavation and trucking activities are estimated to take approximately 50 days.

### 3.6.3 Post-Excavation and Site Reclamation Activities

Site reclamation activities are consistent between Alternative 3 and those described for Alternative 2 in Section 3.5.3.

# 3.6.4 Site Controls and Security

During the Alternative 3 removal and reclamation activities, Site access would be restricted by a fence. Domestic livestock would not be allowed to enter the Site until reclaimed. Once vegetation is re-established and the Site has stabilized, perimeter fencing may be removed. Reclamation activities may take 5 years or more before adequate vegetation has been re-established and final stabilization is achieved.

#### 3.6.5 Stormwater and Erosion Control

As for Alternative 2, stormwater management and erosion control are of significant concern based on the size and the extent of the excavation activities associated with Alternative 3. Controls for Alternative 3 would be consistent with those previously described for Alternative 2 (Section 3.5.5).

# 3.6.6 Operation and Maintenance Activities

Operation and maintenance of the Site during the removal and reclamation activities would be the responsibility of the EPA. After completion of reclamation activities, O&M would be arranged through the Tronox trust fund. The O&M activities would include inspection and maintenance of stormwater and erosion control features for perpetuity. Monitoring and maintenance of revegetation efforts would occur for an estimated 12 years following revegetation. The grades/slopes, cap condition, cap vegetation, erosion control measures, access roads, fencing, and other site O&M would require more frequent inspections and a higher level of scrutiny than the other reclaimed and revegetated areas of the Site. The cap would be inspected for differential settling, erosional rilling and gullying, wildlife damage, unauthorized access, and revegetation success. Repairs and maintenance would be completed accordingly.

# 4.0 ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives is intended to provide the relevant information required to select a preferred remedy. Each alternative was evaluated on the basis of effectiveness, implementability, and cost, as set forth in the NCP and EPA guidance on conducting an EE/CA for a removal action (EPA, 1993). A summary of the analyses of the individual alternatives is included as Table 4-1.

# 4.1 ALTERNATIVE ANALYSIS APPROACH

# 4.1.1 Effectiveness

Effectiveness refers to the ability of an alternative to meet the RAOs. The following criteria are used to evaluate effectiveness:

Overall Protection of Human Health and the Environment – This criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The assessment of overall protection draws on the evaluation of the other criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative would focus on whether a specific alternative achieves adequate protection and would describe how Site risks posed through each pathway addressed by the EE/CA are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation would allow for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

<u>Long-Term Effectiveness and Permanence</u> – This criterion evaluates results of the removal action in terms of the risk remaining at the Site after response objectives have been met. The primary focus of this evaluation would be the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes remaining at the Site.

<u>Short-Term Effectiveness</u> – This criterion evaluates the effects that the alternative would have on human health and the environment during its construction and implementation phase. It includes both radiation exposure risks to the contaminated soils and risks to the workers and communities from construction work and traffic during implementation and the time necessary to complete the action.

<u>Compliance with ARARs</u> – This criterion is used to determine whether each alternative would meet the identified ARARs. The detailed analyses would summarize which requirements are applicable or relevant and appropriate to an alternative and would describe how the alternative meets these requirements.

# 4.1.2 Implementability

This criterion evaluates the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required to construct and provide O&M. The following criteria are used to evaluate implementability:

- Technical feasibility
- Administrative feasibility
- Availability of services and materials

Also considered is the reliability of the technology, the ability to monitor the effectiveness of the remedy, and the ease of undertaking additional remedial actions, if necessary.

### 4.1.3 Cost

Cost estimates were prepared for Alternatives 2 and 3 to compare the alternatives and support remedy selection. The types of costs that were assessed in accordance with 40 CFR 300.430 (e)(9)(iii)(G) include the following: (1) capital costs, including both direct and indirect costs; (2) annual operation and maintenance costs; and (3) NPV of capital and O&M costs. Capital costs were included as 2020 dollars. In accordance with EPA guidance, the cost estimates were prepared to provide a level of accuracy in the range of 50% greater to 30% lower than actual costs.

An NPV analysis relates costs that occur over different time periods to present costs by discounting all future costs to the present value. This allows the cost of removal alternatives to be compared

on the basis of a single figure that represents the capital required in 2020 dollars to construct, operate, and maintain the removal alternative throughout its planned life. The NPV calculations were based on a discount rate of 7% (EPA, 2000b), which represents the average rate of return on private investment before taxes and after inflation. Cost estimate details are located in Appendix I.

The scope and costs presented for the various alternatives are based on the best available information regarding current site conditions and readily available information on the applicability and effectiveness of the selected removal actions. However, uncertainties and data gaps remain because the site characterization was based on a limited number of samples, observations, and analyses. In preparing the cost estimates, conservative assumptions have been used and an overall contingency has been added to each alternative to account for these uncertainties. Changes in the cost elements are likely as new information is available and Site conditions change during the removal action design. Cost assumptions are included in Appendix I.

Actual costs may vary from these estimates depending on variations in actual Site conditions from those estimated including inflation; actual fuel costs; actual insurance and bonding costs; the availability and market costs of materials, equipment, and labor; contractor bid strategy; changes in regulatory requirements; and other unforeseen factors.

CERCLA and the NCP require that every remedy selected must be cost-effective. A removal alternative is cost-effective if its "costs are proportional to its overall effectiveness" (40 CFR 300.430(f) (1) (ii) (D)). Overall effectiveness of a removal alternative is determined by evaluating protectiveness, long-term effectiveness, and short-term effectiveness. Overall effectiveness is then compared to cost to determine whether the remedy is cost-effective.

# 4.2 UNAVOIDABLE IMPACTS COMMON TO ALL ALTERNATIVES

Except for Alternative 1 (No Further Action), each of the removal action alternatives would result in an overall improvement to the local environment. However, for Alternatives 2 and 3, it is important to note that there would be some unavoidable impacts. These include:

Short-term inconvenience to local populations using New Mexico Highway 19; general
disturbance from heavy equipment activity for the assumed construction periods; and
increased truck traffic in the area.

- Disruption of cattle grazing and wildlife access to the removal action areas due to the construction activities and for vegetation re-establishment.
- Long-term O&M activities are required for maintenance of the cover, stormwater diversion measures, revegetation efforts, and fencing.
- Increased risks of traffic fatalities due to off-site trucking of waste material (Table 4-2).
- Increase in greenhouse gas emissions due to off-site and on-site trucking of waste material and clean fill material (Table 4-2).

#### 4.3 ALTERNATIVE 1: NO FURTHER ACTION

The No Further Action Alternative does not provide protection to human or environmental exposure, nor is it considered a permanent remedy because it does not reduce the concentration, volume, or mobility of the hazardous waste on the Site. The No Further Action Alternative has been included as a requirement of the NCP and provides a basis for the comparison of the remaining alternatives. No new activities would occur at the Site under this alternative; however, implementation of Alternative 1, No Further Action, would require the following O&M steps to maintain the existing level of protection:

- Erosion and stormwater control maintenance
- Fencing maintenance and repair

## 4.3.1 Effectiveness

This alternative would not minimize the potential exposure to, or transport of, contaminated soils from the Sections 32 and 33 Mines Site. This alternative would not provide control through treatment of soils with concentrations of Ra-226 above the action level or reduce volume or mobility of contaminants, and thus would not reduce risks to human health or the environment. The resultant risks associated with the No Further Action Alternative would be similar to those that existed at the time of the RSE. Therefore, increased protection of human health and the environment would not be achieved under this alternative.

Surface water discharge from the Site would have continued potential to transport contaminated soils to the downstream watershed. Site workers and visitors would continue to be potentially exposed to windborne and waterborne contaminants. The Site would continue to be unacceptable for livestock grazing use.

Other than routine stormwater pollution prevention plan maintenance, no controls or long-term measures would be implemented to control contaminated soils at the Site under the No Further Action Alternative; therefore, this alternative offers no long-term or short-term effectiveness in reducing potential risks to human and ecological receptors.

The effectiveness of the No Further Action Alternative is considered low for achieving the removal action goals.

# 4.3.2 Implementability

This alternative is easily implemented because there are no construction or permitting considerations. EPA guidance requires that the reliability of the technology be considered along with feasibility. Since the No Further Action Alternative is inherently an unreliable remedy, this criterion is rated low.

#### 4.3.3 Cost

The total net present value cost of Alternative 1 is estimated to be \$262,000 (Appendix I, Table I-1). There are no new direct or indirect capital costs, and annual costs are estimated to be approximately \$15,000 (first 12 years) per year. To determine whether the remedy is cost-effective, the overall effectiveness is compared to cost. Because the overall effectiveness of Alternative 1 is low, the cost-effectiveness of Alternative 1 is low.

# 4.4 ALTERNATIVE 2: EXCAVATION AND OFF-SITE DISPOSAL OF CONTAMINATED SOILS AT A LICENSED LOW-LEVEL RADIOACTIVE WASTE FACILITY

Implementation of Alternative 2, excavation and off-site disposal of contaminated soils at a licensed low-level radioactive waste facility, would require the following steps:

- Excavation of all radiologically-contaminated wastes above the ALs (Figure 2-1).
- Off-site disposal of excavated contaminated soils.
- Site reclamation with erosion and stormwater controls, re-contouring and revegetation.

## 4.4.1 Effectiveness

Alternative 2 would provide a high level of protection to human health and the environment. All soil above the action level would be excavated within the Site boundary and removed for off-site transportation and disposal at a licensed, low-level radioactive waste facility. This alternative would significantly minimize potential exposure to contaminated soils from the Site. This alternative would provide control of mobility and a reduction in risk to human health and the environment at the Site. Potential exposures during excavation, transport, and at the final disposal site would be managed through engineering controls.

The activities set forth for the removal action would provide compliance with location-specific ARARs. A Cultural Resources Protection Plan would be developed for monitoring protocols during work activities and would include a review and evaluation of potential impacts to historic properties and locations. Natural resource (e.g., biological and botanical) surveys have been conducted at the Site and information from these surveys would be included in the Environmental Protection Plan. The plan would include a review and evaluation of potential impacts on government-protected species and critical habitats

Federal and state ARARs would be met for the Site under Alternative 2. Action-specific ARARs for this alternative include federal and state hazardous waste management regulations to the extent applicable; federal and state standards for protection of workers, the public, and the environment from low-level radioactivity; the New Mexico Administrative Code (NMAC) 20.2 for air quality control regulations; and federal rules and regulations pertaining to the on-site accumulation of wastes in stockpiles and the control of stormwater discharges during construction activities. The U.S. Department of Transportation rules and regulations on manifesting and the on-site and off-site transport of hazardous materials would also be action-specific ARARs for implementation of Alternative 2. Federal requirements for hazardous waste disposal would be ARARs if the removal action encounters wastes subject to these requirements.

Short-term effectiveness under Alternative 2 is medium because of the disturbance of the entire waste area and the large amount of trucking to transport the entire amount of waste. The primary considerations for short-term effectiveness are protection of the community and workers, and protection against environmental impacts during and after implementation. Alternative 2 involves

excavation, material transfer, stockpile development/management, loading of bulk carriers, and site restoration activities. Heavy construction equipment would be used to clear and grub, excavate, transfer, load, and grade impacted materials. Potential exposure and protection procedures for workers engaged in these activities would be addressed in detail under a Site Health and Safety Plan. During excavation and material handling activities, measures would be taken to reduce fugitive dust emissions and associated impacts to workers. Water would be used for dust control, and workers in the controlled area would don the appropriate safety equipment and implement safety practices such as air monitoring. Work areas would be secured (e.g., marked or fenced) to ensure access by authorized personnel only.

Bulk carriers hauling the removal action-derived contaminated wastes off-site would be covered, secured, and weighed to document compliance with total and axle load limits. Truck traffic would be coordinated under an Off-Site Transportation Plan for routes, times of operation, and on-site traffic rules. Emergency spill containment and cleanup contingencies would also be included in the Transportation Plan to address material spills. Due to the large number of truckloads (approximately 7,300 loads of contaminated soil leaving the Site) and the long drive to the disposal facility (up to 5 hours one-way), it is estimated that the time period of implementation of Alternative 2 would be 1 year following 8 months of planning and permitting. This alternative also has the highest amount of trucking and heavy equipment use in vehicle hours; therefore, it has the highest potential for additional vehicular accidents, for increased wear and tear on infrastructure, for the production of the highest amount of fossil fuels. A risk of 0.13 additional fatalities and 14,573 metric tons of greenhouse gas emissions, calculated as a carbon dioxide equivalent (CO<sub>2</sub>e), are estimated due to the increased truck traffic (see Table 4-2).

Long-term effectiveness of this alternative is high. Since all contaminated soils would be excavated and removed from the Site, potential exposure reductions to those accessing the Site would be permanent. Alternative 2 is expected to effectively mitigate the long-term effects on potential on-site human and ecological receptors.

# 4.4.2 Implementability

Alternative 2 rates medium in technical and administrative implementability. Although it is technically feasible and would use conventional techniques, materials, or labor for the excavation and associated activities, and the extended schedule (approximately 1 year and 8 months) to complete excavation and disposal reduces its implementability rating. The Site is readily accessible. Excavation would be scheduled and performed to maximize direct loading and ensure worker and public safety. Engineering controls for fugitive dust and site monitoring would be used to control potential exposures to sensitive receptors. Profiling and manifesting of the material would be done in coordination with the transporters and off-site disposal facility. Rail shipment is a possibility; a trans-load facility to transfer material from trucks to railcars could be established as close as 10 miles from the Site. The cost of setting up the facility, stationing an excavator with a scaling bucket, maintaining a water supply for dust control, providing security at the Site, and scheduling would need to be evaluated against the cost of trucking.

Alternative 2 would be administratively feasible since the shipping of waste is fairly common and would only require scheduling and obtaining the necessary permits. All contaminated soil is anticipated to be accepted by permitted facilities, although due to the large quantity of material to be disposed off-site, it is possible that one facility may not ultimately be able to accept all of the waste.

The excavation of contaminated material would be accomplished using a variety of conventional equipment. Heavy construction equipment needed for this project such as scrapers, excavators, dozers, loaders, and compactors and/or bulk carriers are commercially available. Working space is available for establishing temporary construction office trailers. Electricity is already available at the Site and portable sanitary services and refuse disposal are locally available. Construction materials for the Site reclamation activities (localized drainage structures, erosion control, re contouring, and seeding), and an off-site laboratory for sample analysis are commercially available.

Trained and experienced labor is available for Site work activities. Special certifications and training requirements are commercially available. Health and safety training to comply with OSHA regulations, including radiation and hazardous material handling training, is available.

On-site water would be required for construction purposes. It would be obtained from Grants or another nearby community.

### 4.4.3 Cost

The total net present value cost of Alternative 2 is estimated to be \$50,918,000 (Appendix I, Table I-2). The overall effectiveness is compared to cost to determine whether the remedy is cost-effective. The long-term effectiveness and permanence is high while the short-term effectiveness is medium. Because the cost is very high, the cost-effectiveness of Alternative 2 is low.

# 4.5 ALTERNATIVE 3: CONSOLIDATION AND CAPPING OF CONTAMINATED SOILS IN PLACE

Implementation of Alternative 3, consolidation and capping of contaminated soils in place, would require the following steps:

- Design, siting, and construction of an aboveground cap.
- Excavation of all excess radiologically contaminated wastes outside of the capped footprint and placement of that material in the capping area.
- Excavation and transportation of clean-soil cap material.
- Construction of an engineered, clean-soil cap over the contaminated area.
- Site reclamation with erosion and stormwater controls, re-contouring, and revegetation.

# 4.5.1 Effectiveness

Alternative 3 would provide a high level of protection of human health and the environment as all contaminated soils would exist or be placed within a capped area designed to attenuate radiological risk for residential land use. These activities would prevent direct contact between wastes, humans, and the environment in the future. Long-term maintenance of the cover and stormwater infrastructure would be necessary.

Federal and state ARARs would be met for the Site under Alternative 3. The capped area would include a cover to fully contain and isolate contaminated soils. Stormwater controls would be included in the design so that surface water would be diverted from the area. The cover is a physical barrier that offers protection from water infiltration to the contaminated soils, protects groundwater

resources, and also provides adequate shielding from ionizing radiation to protect human health and the environment.

The activities set forth for the removal action would provide compliance with location-specific ARARs. A Cultural Resources Protection Plan would be developed for monitoring protocols during work activities and would include a review and evaluation of potential impacts to historic properties and locations. Natural resource (e.g., biological and botanical) surveys have been conducted at the Site and information from these surveys would be included in the Environmental Protection Plan. The plan would include a review and evaluation of potential impacts on government-protected species and critical habitats.

The removal action would provide compliance with action-specific ARARs. These include federal and state hazardous waste management regulations, to the extent applicable; federal and state standards for protection of workers, the public, and the environment from low-level radioactivity; the NMAC 20.2 for air quality control regulations; and federal rules and regulations pertaining to on-site accumulation of stockpiled wastes, protection and monitoring of groundwater, and the control of stormwater discharges during construction activities, to the extent applicable.

Short-term effectiveness under Alternative 3 is high. The primary considerations in the rating for short-term effectiveness are protection of the community and workers, and environmental impacts during and after implementation. Alternative 3 involves excavation, material transfer, stockpile development/management, loading of bulk carriers, and Site reclamation activities. Heavy equipment would be used to clear and grub, excavate, transfer, load, and grade impacted materials. Potential exposure and protection procedures for workers engaged in these activities would be addressed in detail under a Site safety and health plan. During excavation and material handling activities, measures would be taken to reduce fugitive dust emissions and associated impacts to workers. Water would be available on-site for dust control, and workers in the controlled area would don the appropriate safety equipment and implement safety practices such as air monitoring. Work areas would be secured (e.g., marked or fenced) to control access by authorized personnel only.

On-site truck traffic would be coordinated under the previously referenced Traffic Control Plan for the Site. On-site truck accidental spill containment and cleanup procedures would be included in the aforementioned plan. Due to the volume of waste to be moved within the Site to the capped area, it is estimated that the time period of implementation of Alternative 3 would be approximately 1 year following 6 months of securing land access agreements, permitting, and planning. A risk of 0.00 additional fatalities and 192 metric tons of greenhouse gas (CO<sub>2</sub>e) emissions are estimated due to the increased truck traffic (see Table 4-2).

The long-term effectiveness of Alternative 3 is medium because it is dependent on the future maintenance activities at the capped area. If properly maintained, the cover and diversion structures would minimize water infiltration and the cap would prohibit human or animal disturbance to the contaminated soils.

# 4.5.2 Implementability

Alternative 3 rates high in regards to technical implementability. It is technically feasible and would require conventional techniques, materials, and labor for the excavation and associated activities since the Site is readily accessible. Excavation would be scheduled and performed to maximize direct loading and ensure worker and public safety. Engineering controls for fugitive dust and Site monitoring would be used to control potential exposure to human and environmental receptors.

Alternative 3 is administratively feasible. The contaminated soils would be transported within the Site boundary, which would include the capped area. Transportation permits would not be necessary. Construction of an engineered cover would not require permitting because contaminated soils are considered low-level radioactive materials and are not a RCRA hazardous waste. In addition, permits are not required for on-site CERCLA actions. On-site CERCLA actions must comply with the substantive requirements of any state or local permit, but not the administrative requirements.

The excavation of contaminated material would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project such as scrapers, excavators, dozers, loaders, and compactors and/or bulk carriers are commercially available. Working space is available for establishing temporary construction office trailers. Electricity is already available at the Site and portable sanitary services and refuse disposal are locally available. Construction materials for the cover and Site restoration activities (re-contouring and seeding), and an off-site laboratory for

sample analysis are commercially available. During non-construction periods, best management practices would be employed in accordance with stormwater control plans to help secure the Site during extreme storm events to protect human health and wildlife. On-site water would be required for construction purposes. It would be obtained from Grants or another nearby community.

Trained and experienced labor is available for Site work activities. Special certifications and training requirements are commercially available. Health and safety training to comply with OSHA regulations, including radiation and hazardous material handling training, is available.

### 4.5.3 Cost

The total net present value cost of Alternative 3 is estimated to be \$13,835,000 (Appendix I, Table I-3). The overall effectiveness is compared to the cost to determine whether the remedy is cost-effective. The long-term effectiveness is medium and the short-term effectiveness is high. The cost-effectiveness of Alternative 3 is medium.

# 5.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This Section of the EE/CA provides a comparison of the three removal action alternatives and options as described in Section 3 using the analyses presented in Section 4. Alternatives screened from further consideration are not compared. In addition, and based on EPA guidance, there are five core (key) elements in "greener cleanup activities" that should be considered throughout the remedy selection process (EPA, 2016). These key elements include: minimizing total energy use and increasing the percentage of renewable energy; minimizing air pollutants and greenhouse gas emissions; minimizing water use and negative impacts on water resources; protecting ecosystem services; and improving materials management and waste reduction efforts by reducing, reusing, or recycling whenever feasible (EPA, 2012). This analysis compares the effects each removal action alternative, described in Section 3, has on the five key "green" elements. Each of the five elements was qualitatively scored for each alternative using a numerical ranking system 1 to 5, with 1 being best and 5 being worst (i.e., low scores are greener cleanup alternatives). The alternative's Greener Cleanup Assessment Score was derived from the sum of the five scores for that alternative. The results of this assessment are summarized in Appendix L.

# **5.1 EFFECTIVENESS**

Alternative 1: No Further Action does not protect human health of ranchers or recreational visitors (hunters) to the Site nor does it protect the environment. The effectiveness of this alternative is low. Alternative 2: Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility and Alternative 3: Consolidation and Capping of Contaminated Soils in Place each protect human health of ranchers and hunters to the Site, and the environment, and are individually rated high for this metric. The Site would be suitable for residential use under Alternatives 2 and 3. Any chance for exposure would occur prior to and during removal activities. Residential use may or may not be limited based on erosion and vegetation performance and cover maintenance requirements.

Alternatives 2 and 3 comply with the ARARs and are equal under this criterion. Alternative 1 retains the greatest chance for contaminant mobility and would rank below the other alternatives.

The short-term effectiveness is considered medium for Alternative 2 and high for Alternative 3. Alternative 3 requires excavation and capping of the consolidated contaminated soil volume; however, Alternative 2 requires a massive transportation effort to remove all contaminated soil off-site. Alternatives 3 does not require off-site transport of the waste, but contaminated soil would need to be transported to the capping area. Alternatives 2 and 3 would have a potential impact to workers and on-site visitors during construction activities. The number of trucks required to transport the contaminated soil to an off-site disposal facility for Alternative 2 would increase risk of traffic accidents and increase the carbon footprint, whereas Alternative 3 would introduce a much lower risk for traffic accidents and greenhouse gas emissions.

Under each of the action alternatives, engineering controls would prevent off-site impacts from materials such as windborne dust. Alternative 1 has the lowest short-term and long-term effectiveness, is not considered a permanent solution, and is ranked low. Alternative 2, ranked high, provides better long-term effectiveness and permanence because the waste would be managed in a location with waste from other sites and would be managed by a third party. Alternative 3 is ranked medium for long-term effectiveness and permanence. Although waste would be managed in a capped area, maintenance of the cover would be required.

# 5.2 IMPLEMENTABILITY

Implementation of Alternative 1, No Further Action, is ranked low because no action is taken. Alternative 2 is technically feasible to implement and would use conventional techniques, materials, and labor for the excavation and associated activities. However, Alternative 2 requires a large amount of off-site trucking, and providing enough trucks each day to maintain production levels may be difficult to schedule and obtain. Alternative 2 is ranked medium for implementability.

Alternative 3 is easily implemented as it is technically feasible and would use conventional construction techniques, materials, or labor for the excavation and associated activities. Alternative 3 is technically feasible but administratively would require a site-specific, unique compliance standard, as the MARSSIM (EPA, 2000b) does not address subsurface soils. Alternative 3 is ranked medium for implementability and Alternative 2 is ranked medium for implementability.

All action alternatives require a large amount of water for dust control and revegetation efforts. Water is available at Grants, New Mexico, and potentially closer to the project site. Additional sources of water should be investigated during the planning phase.

# 5.3 COST EFFECTIVENESS

Alternative 1 only involves O&M costs to maintain existing fencing and is the least expensive option, however it does not address risks posed by leaving contaminated material in its current state. Alternative 2, removing the waste from the Site and disposing of it in a licensed low-level radioactive waste facility, has the highest long-term effectiveness; however, because of the very high cost associated with this alternative, it has a low cost-effectiveness rating compared to Alternative 3. Alternatives 2 and 3 would allow unrestricted use of the Site. Alternative 3, which involves on-site consolidation of wastes, is the most cost-effective.

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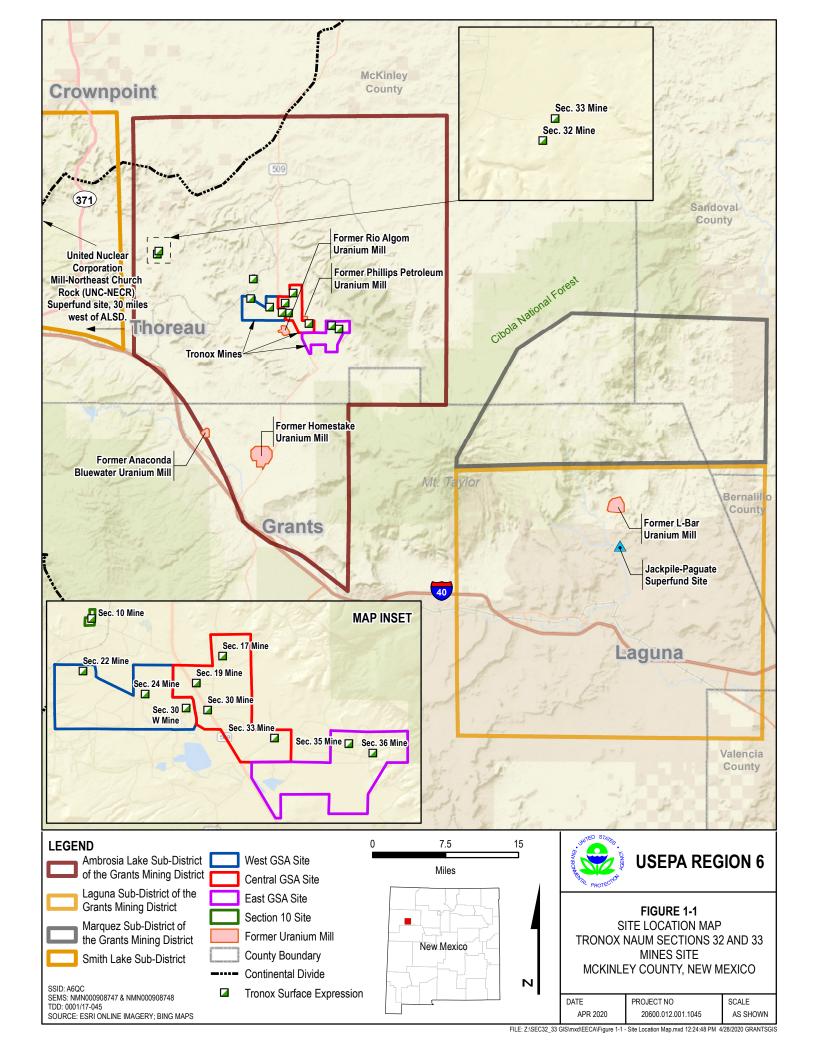
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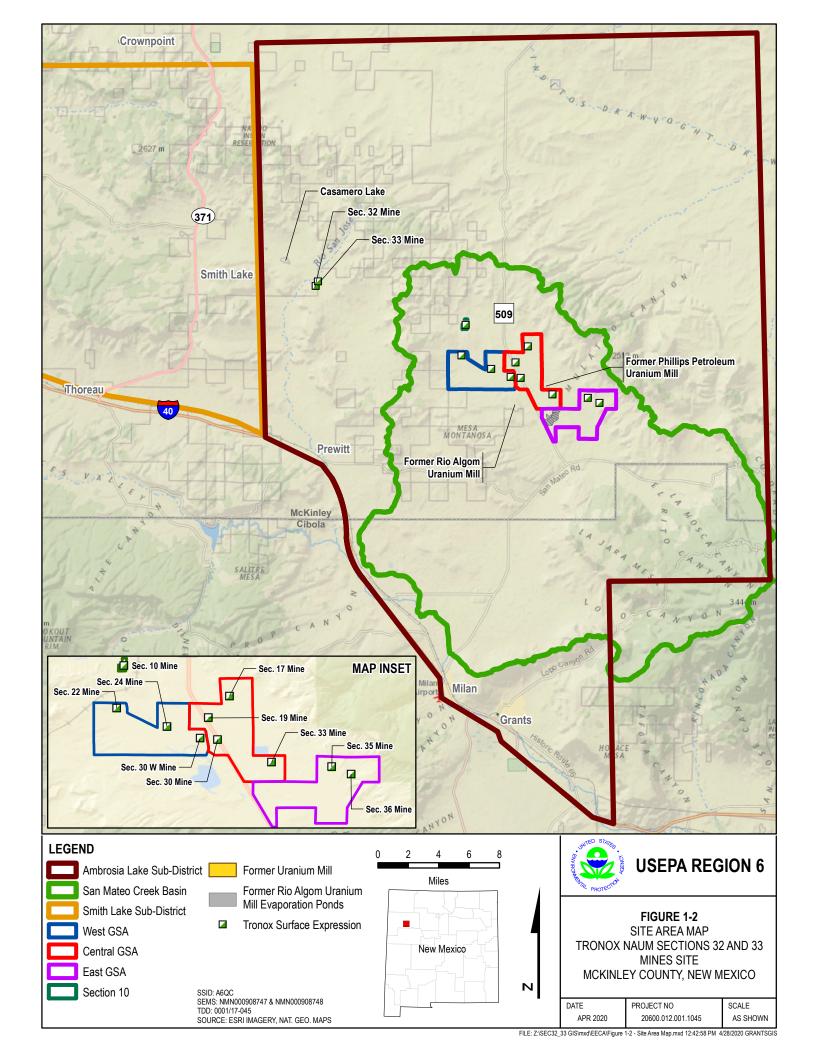
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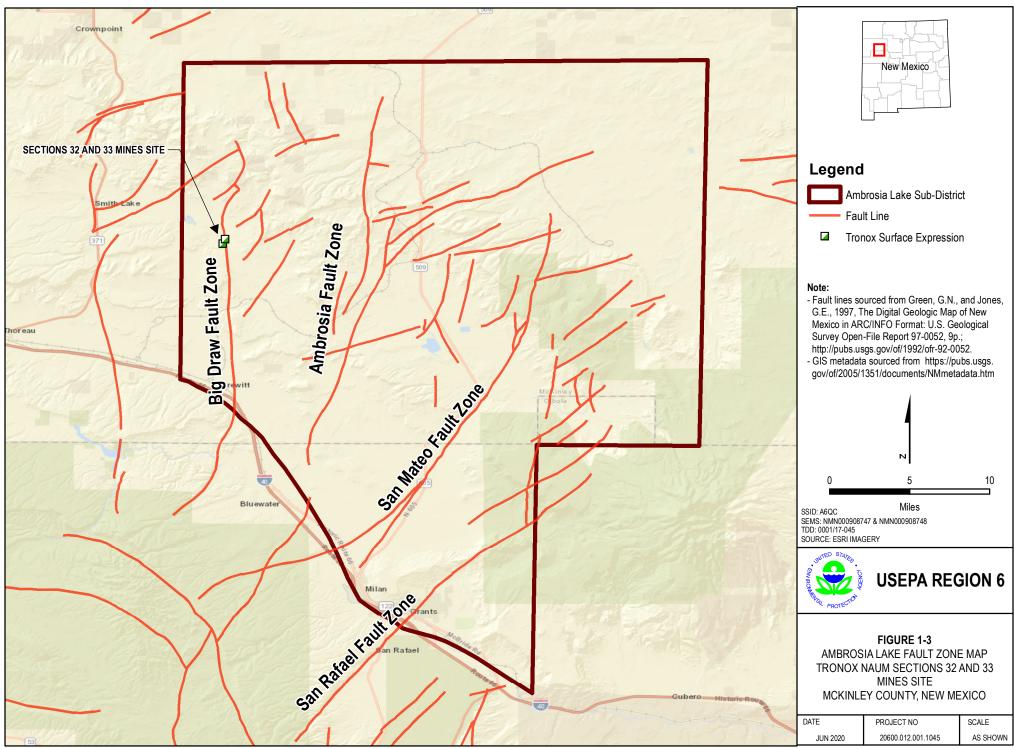
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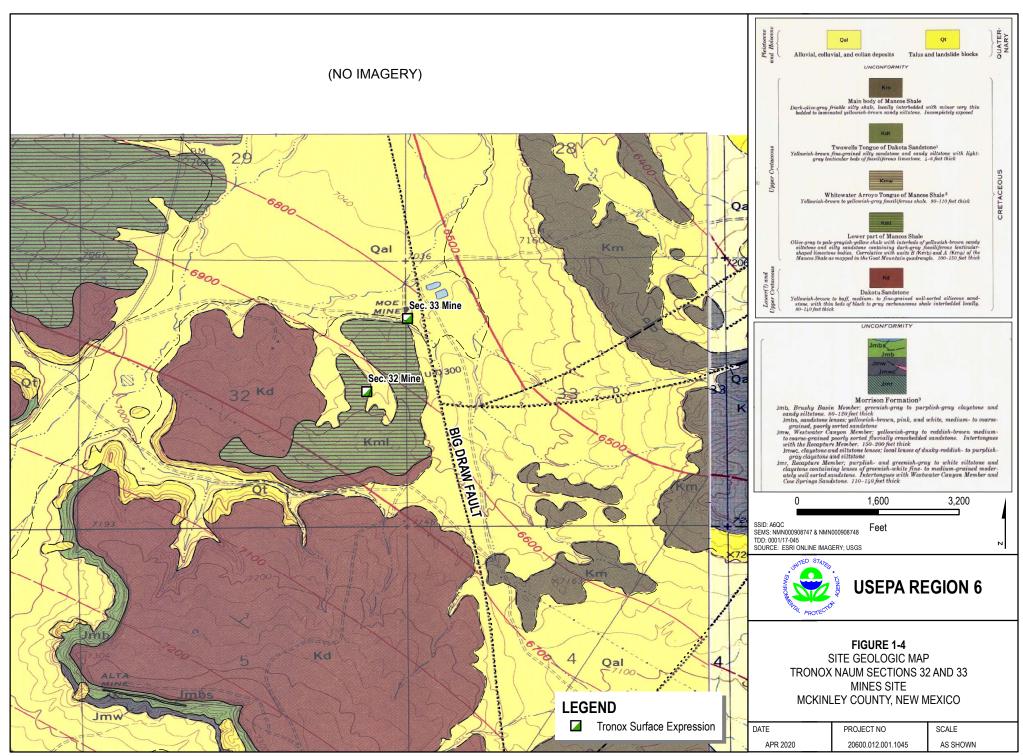
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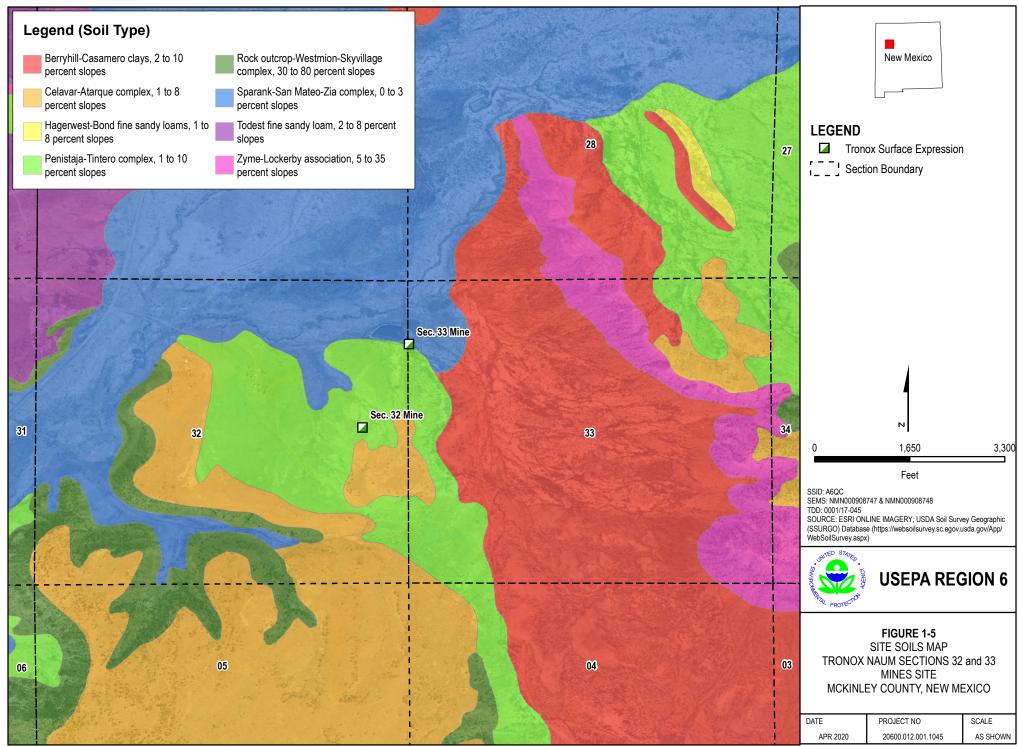


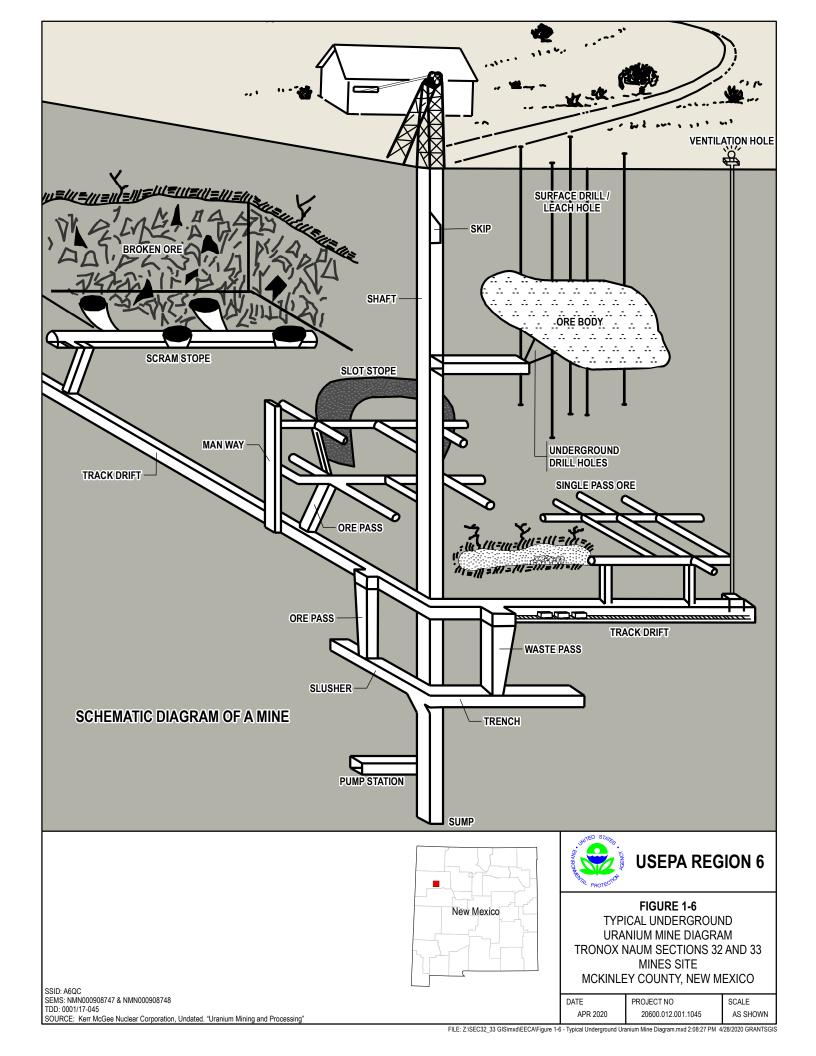


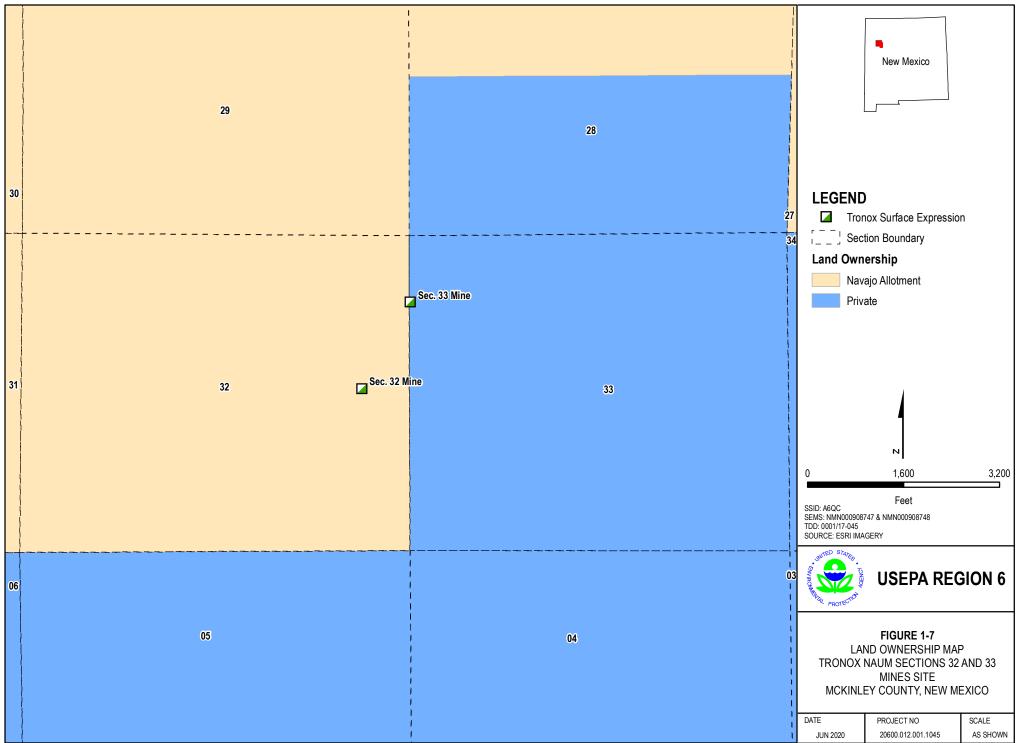


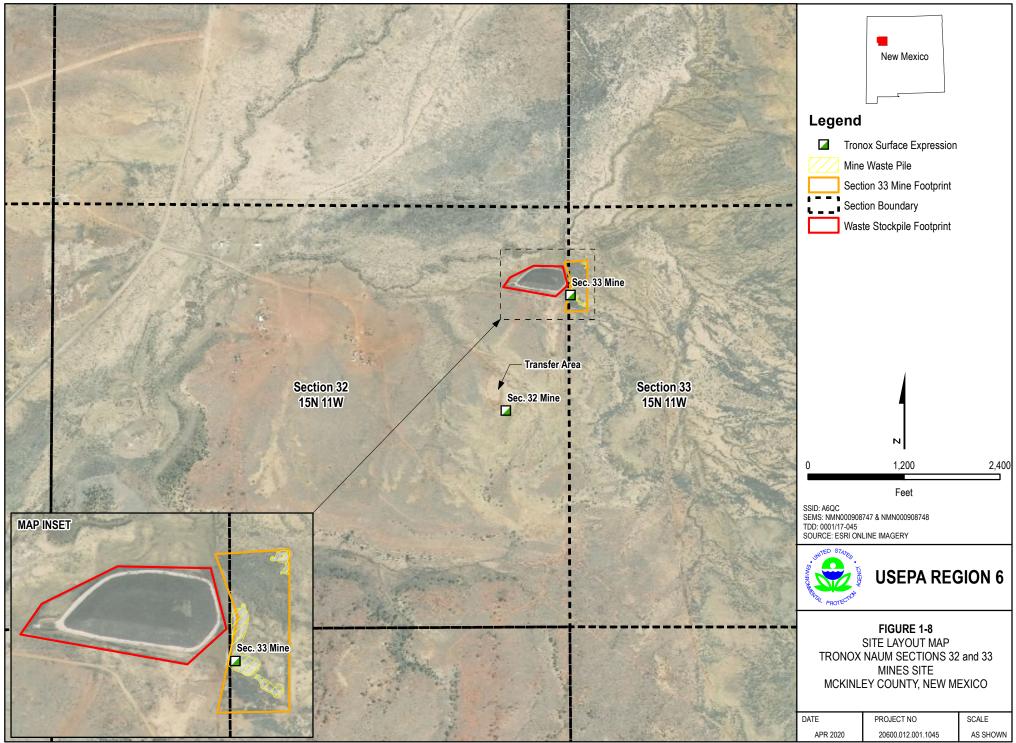


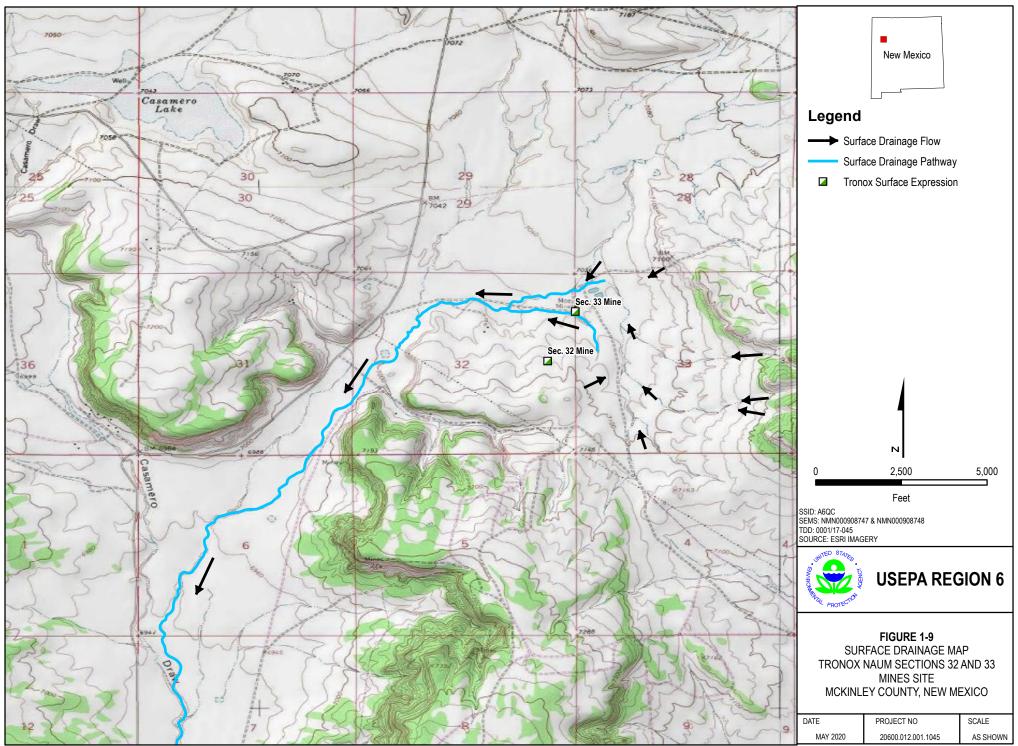


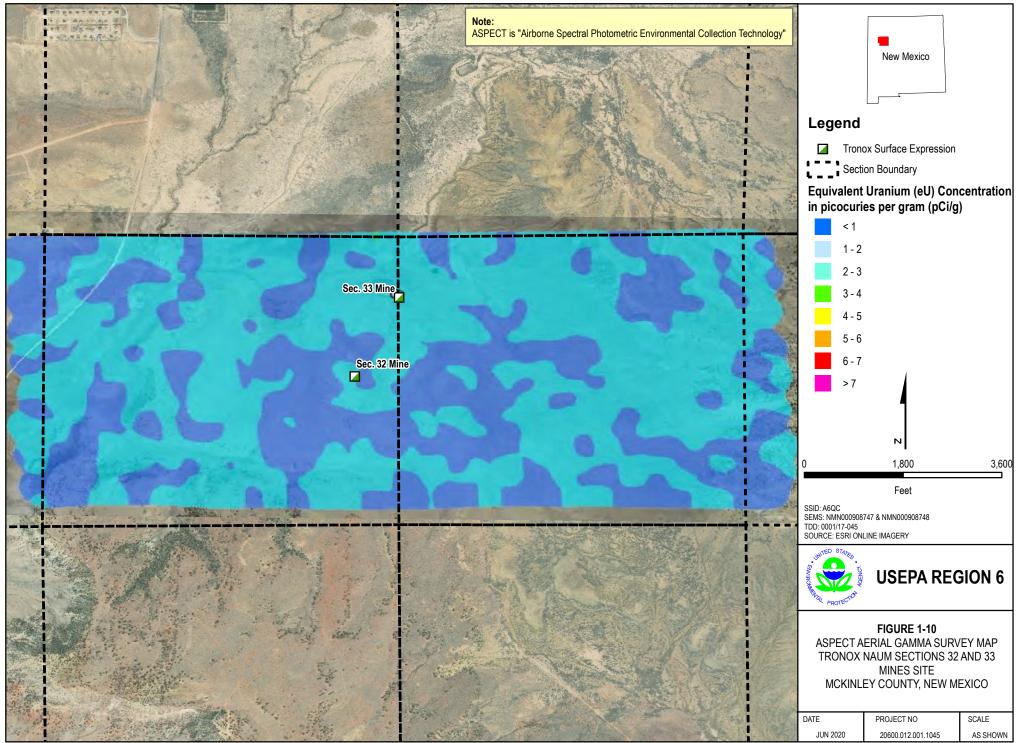


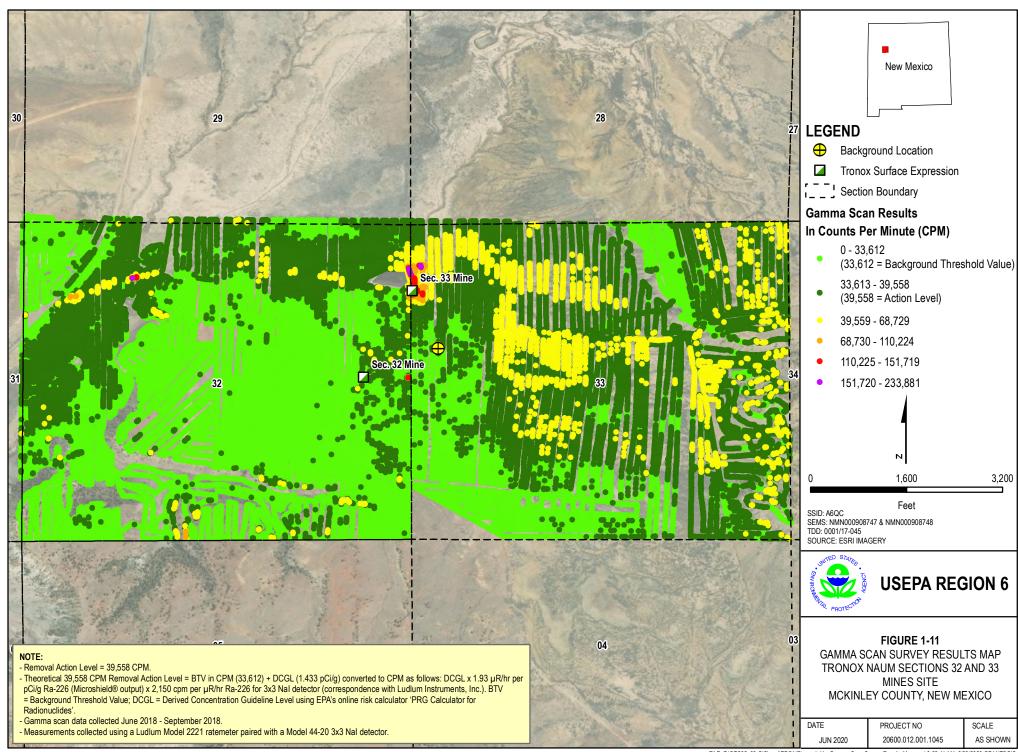


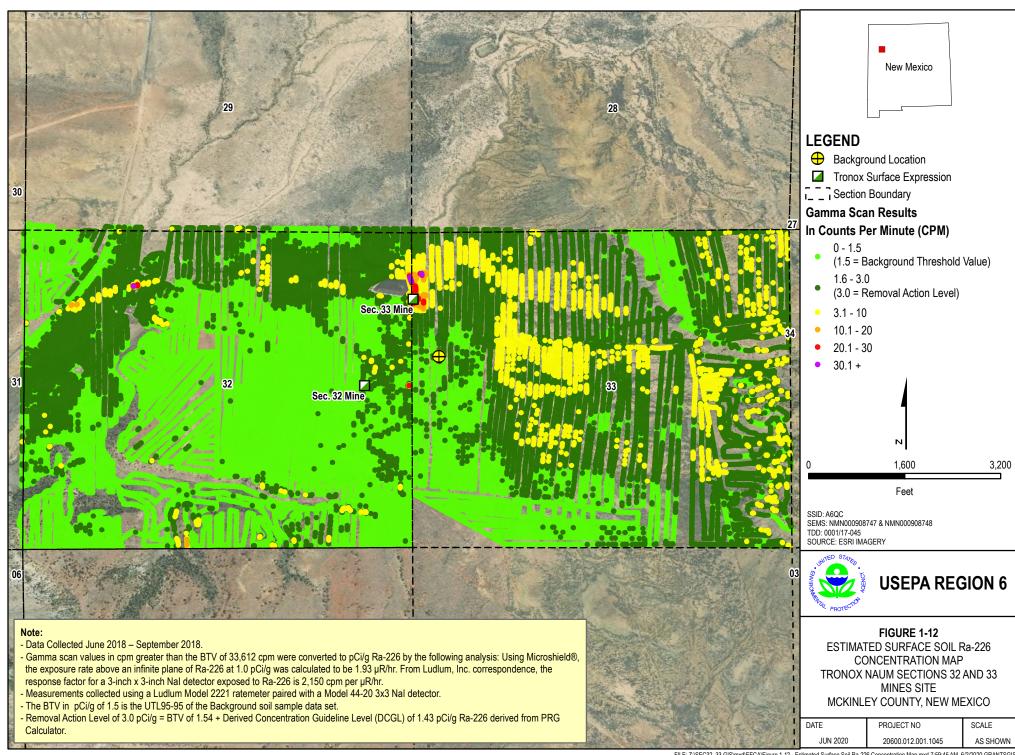


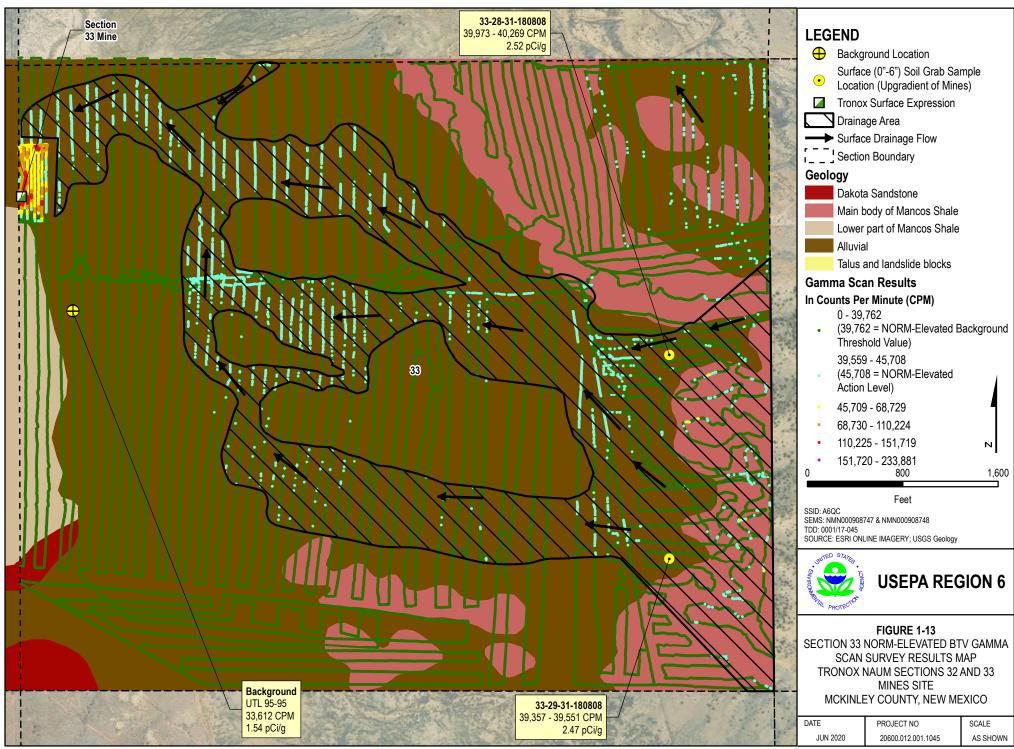


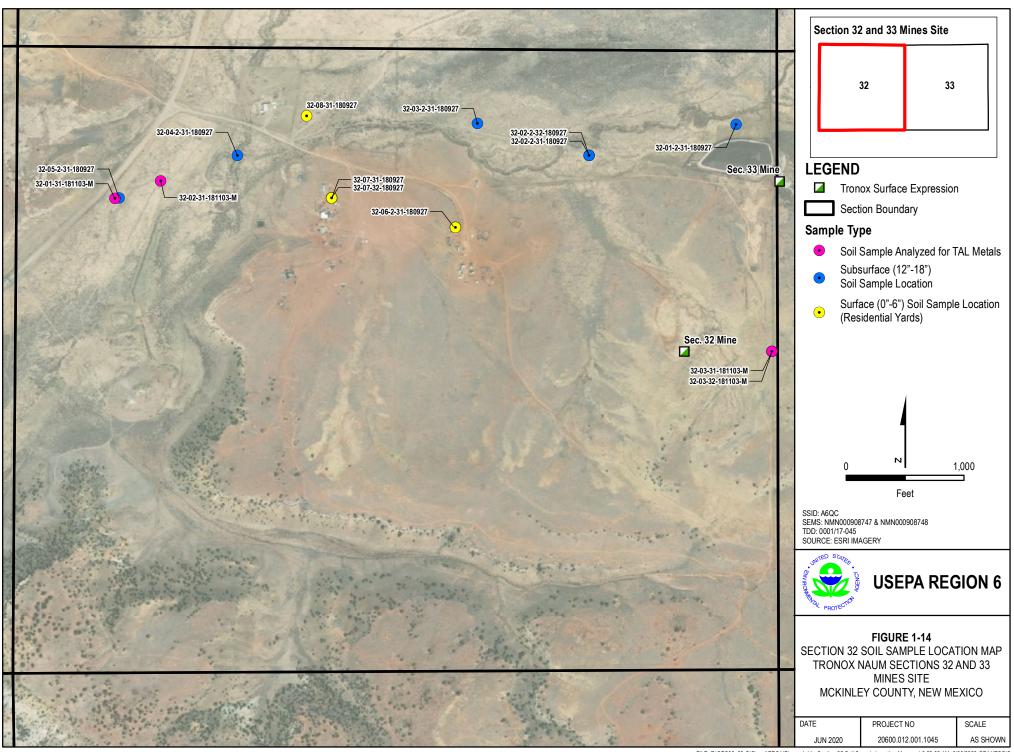


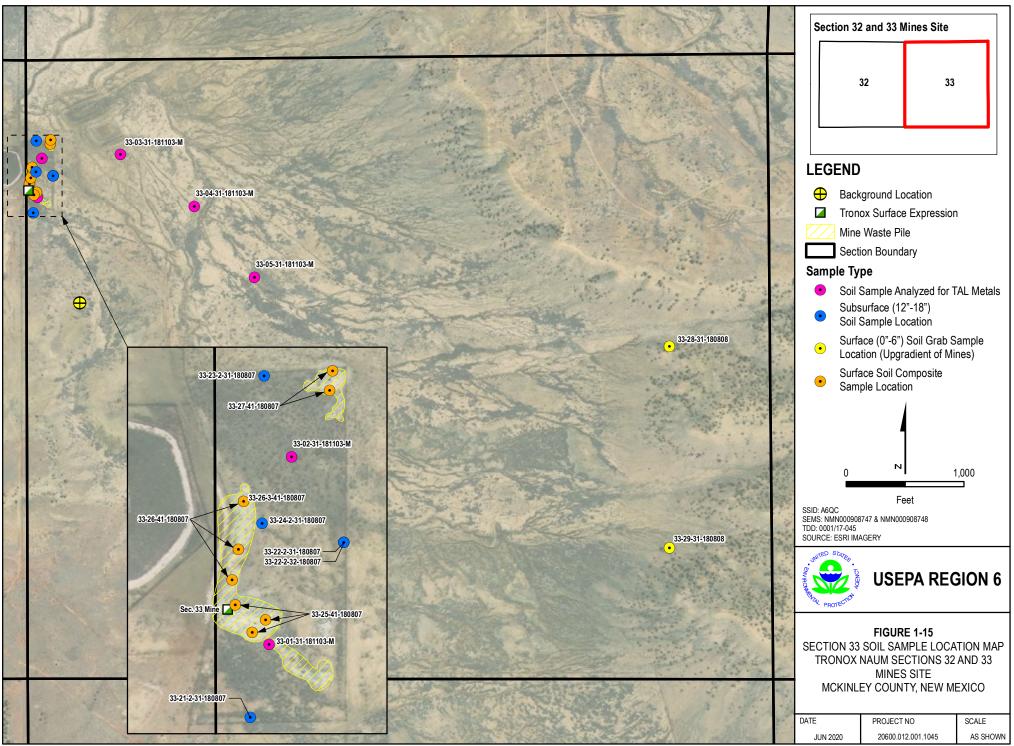


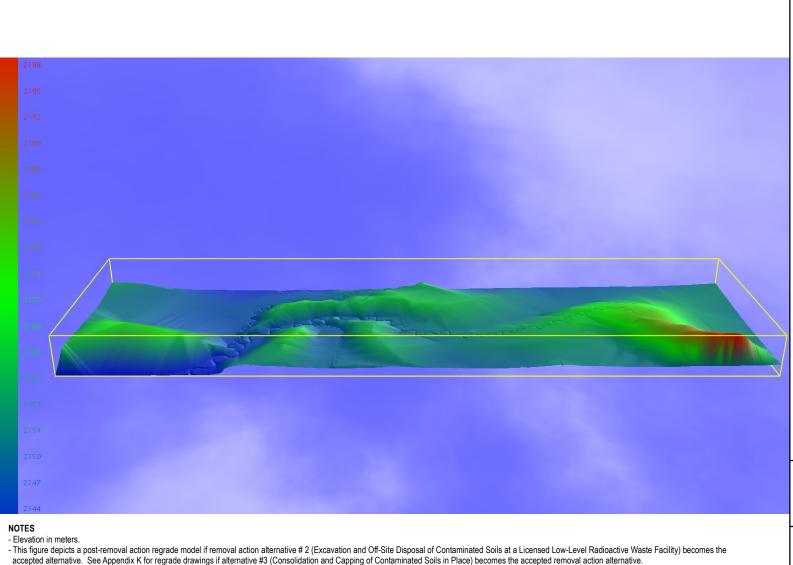




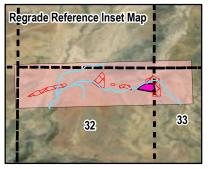












### **LEGEND**

Approximate Channel Location

0-2 foot Excavation Depth Area

Approximate Regrade Area

Section 32 Waste Stockpile Footprint

Section Boundary

SSID: A6QC SEMS: NMN000908747 & NMN000908748 TDD: 0001/17-045 SOURCE: CARLSON NATURAL REGRADE WITH GEOFLUV

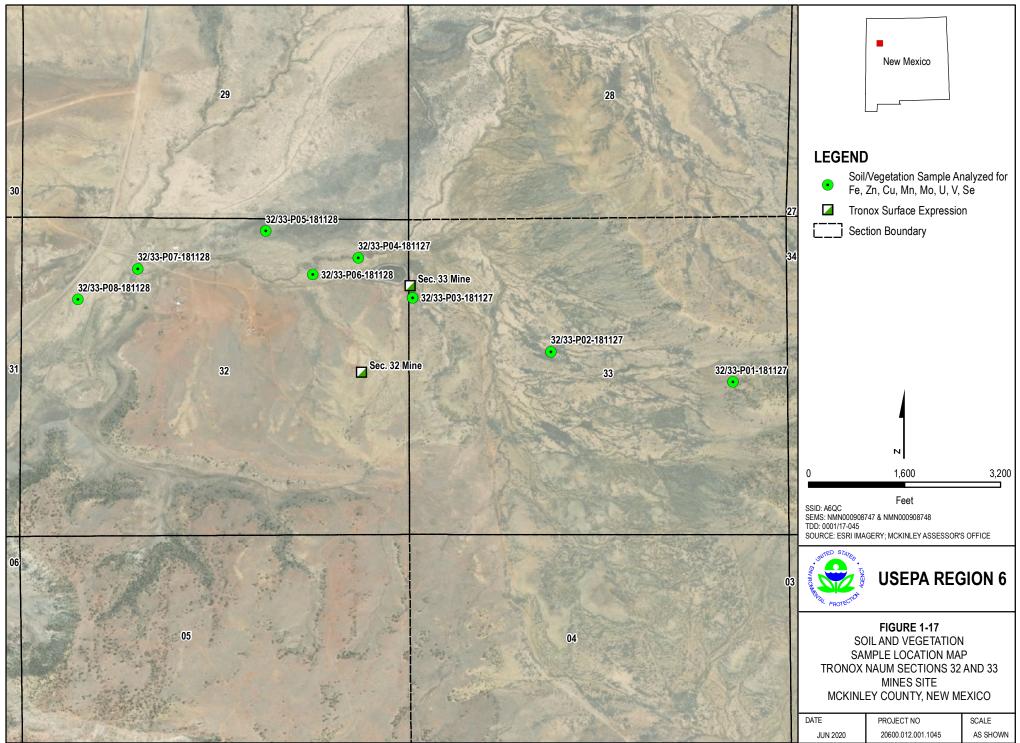


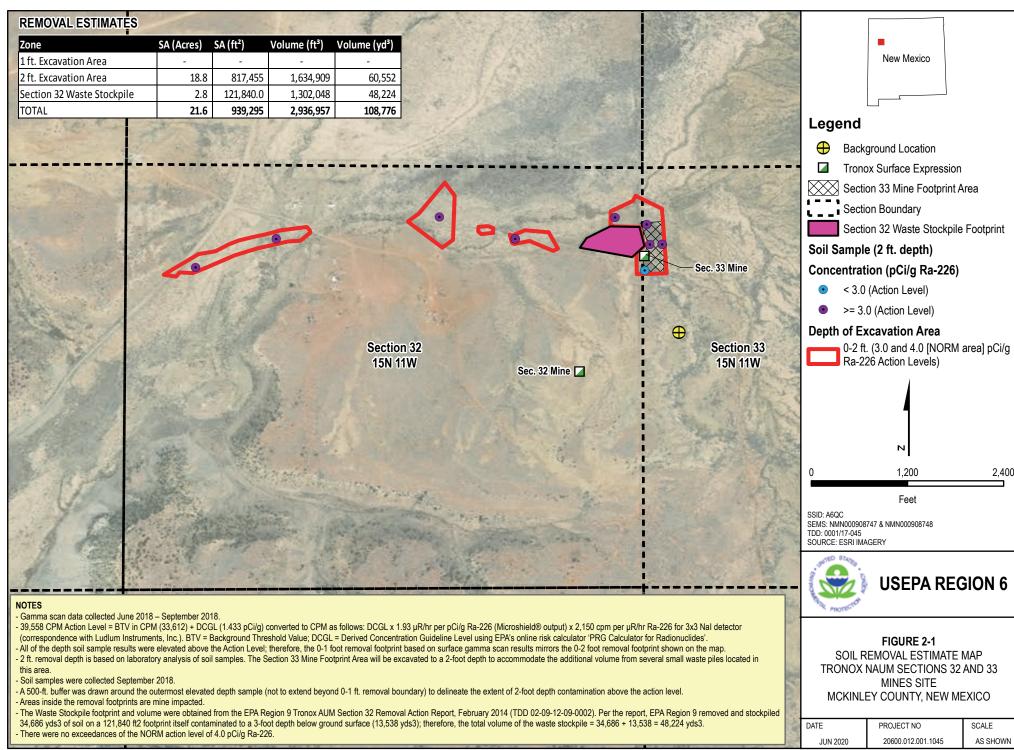
## **USEPA REGION 6**

FIGURE 1-16
REGRADE MODEL
TRONOX NAUM SECTIONS 32 AND 33
MINES SITE
MCKINLEY COUNTY, NEW MEXICO

 DATE
 PROJECT NO
 SCALE

 JUN 2020
 20600.012.001.1045
 AS SHOWN





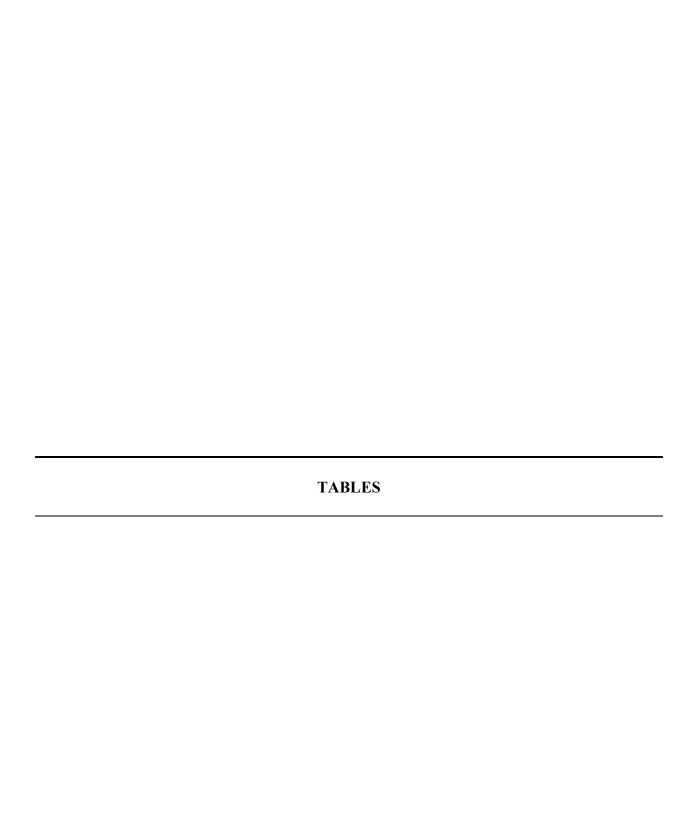


Table 1-1

Background Reference Area Summary of Field and Laboratory Measurements

Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site

McKinley County, New Mexico

	<sup>1</sup> Ludlum 3"x3" Nal One-Minute Stationary	Laboratory Gamma Spectroscopy Result
	Measurement	Radium-226
	(counts per minute	(picocuries per gram
Sample ID	[cpm])	[pCi/g])
33-01-61-180620	32,315	1.26
33-02-61-180620	32,141	1.10
33-03-61-180620	32,396	0.98
33-04-61-180620	32,292	1.20
33-05-61-180620	32,898	1.33
33-06-61-180620	32,929	1.18
33-07-61-180620	31,888	1.39
33-08-61-180620	32,061	1.34
33-09-61-180620	31,990	1.01
33-10-61-180620	32,359	1.22
33-11-61-180620	32,639	1.15
33-12-61-180620	31,484	1.31
33-13-61-180620	31,225	1.37
33-14-61-180620	31,717	1.44
33-15-61-180620	32,253	1.34
33-16-61-180620	31,602	1.14
33-17-61-180620	30,965	1.22
33-18-61-180620	30,192	1.29
33-19-61-180620	30,580	1.17
33-20-61-180620	31,538	1.02
Mean	31,873	1.223
Standard Deviation	726	0.131
Coefficient of Variance	0.0228	0.107

<sup>&</sup>lt;sup>1</sup>One-minute stationary gamma measurements were collected with a Ludlum Model 2221 Rate Meter attached to a Model 44-10 Sodium Iodide (NaI) 3-inch by 3-inch Scintillator Probe.

Page 1 of 1 TDD No. 0001/17-045

### Table 1-2

# Surface Soil Samples - Gamma Spectroscopy Results Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines McKinley County, New Mexico

					Radium (picocuries per		
Sample ID <sub>1,2,3</sub>	Latitude	Longitude	Collection Method	Sample Type	Field Laboratory Multichannel Analyzer (MCA) <sub>4,5</sub>	Off-site Laboratory <sub>4,5,6</sub>	Figure Depicting Sample Location
32-06-31-180927	35.489007	-108.024445	Grab	Field Sample	1.9	1.53	1-14
32-07-31-180927	35.489689	-108.027325	Grab	Field Sample	2.0	1.63	1-14
32-07-32-180927	35.489689	-108.027325	Grab	Field Duplicate	2.0	1.55	1-14
32-08-31-180927	35.489689	-108.027325	Grab	Field Sample	2.5	2.11	1-14
33-25-41-180807	35.490104	-108.016866	Composite	Field Sample	32.6	n/a	1-15
33-26-41-180807	35.490228	-108.016882	Composite	Field Sample	47.7	52.7	1-15
33-27-41-180807	35.491156	-108.016403	Composite	Field Sample	28.4	n/a	1-15
33-28-31-180808	35.486452	-108.002453	Grab	Field Sample	4.4	2.52	1-15
33-29-31-180808	35.481759	-108.001005	Grab	Field Sample	4.5	2.47	1-15

#### Notes:

- <sub>1</sub> All samples collected from 0-6 inches below ground surface.
- <sup>2</sup> First two digits of the sample number indicate the section from which they were collected.
- <sub>3</sub> The average (2.5 pCi/g Ra-226) of off-site laboratory results for samples 33-28-31-180808 and 33-29-31-180808 was used to represent Naturally Occurring Radioactive Material (NORM) in Section 33 (see section 1.4.2.2 of EECA.
- <sup>4</sup> MCA and off-site laboratory both analyzed for Bismuth-214. Samples were held before analysis so that Bismuth-214 was in equilibrium with Radium-226.
- <sub>5</sub> Sample results above the 3.0 pCi/g Ra-226 and 4.0 pCi/g Ra-226 (Section 33 NORM-affected area) Action Levels are shaded in gray. Where a sample has both an MCA and off-site laboratory result, the off-site laboratory result was used for all decisions, extent-of-contamination estimates, and calculations.
- <sub>6</sub> n/a denotes that the sample was not sent for off-site laboratory analysis.



## **USEPA REGION 6**

Table 1-3
Subsurface Soil Samples - Gamma Spectroscopy Results
Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site
McKinley County, New Mexico

					Radium 226 (picocuries per gram [pCi/g]) <sub>5</sub>		Figure
					Field Laboratory		Depicting
Canada ID			Collection		Multichannel	Off-site	Sample
Sample ID <sub>1,2</sub>	Latitude	Longitude	Method	Sample Type	Analyzer (MCA) <sub>3,4</sub>	Laboratory <sub>3,4,5</sub>	Location
32-01-2-31-180927	35.4914	-108.018	Grab	Field Sample	3.5	n/a	1-14
32-02-2-31-180927	35.49068	-108.021	Grab	Field Sample	3.4	n/a	1-14
32-02-2-32-180927	35.49068	-108.021	Grab	Field Duplicate	3.6	n/a	1-14
32-03-2-31-180927	35.49143	-108.024	Grab	Field Sample	3.3	n/a	1-14
32-04-2-31-180927	35.49068	-108.03	Grab	Field Sample	3.4	n/a	1-14
32-05-2-31-180927	35.48969	-108.032	Grab	Field Sample	3.6	n/a	1-14
33-21-2-31-180807	35.48955	-108.017	Grab	Field Sample	2.6	n/a	1-15
33-22-2-31-180807	35.49041	-108.016	Grab	Field Sample	3.5	n/a	1-15
33-22-2-32-180807	35.49041	-108.016	Grab	Field Duplicate	3.8	n/a	1-15
33-23-2-31-180807	35.49123	-108.017	Grab	Field Sample	5.5	3.77	1-15
33-24-2-31-180807	35.49051	-108.017	Grab	Field Sample	4.6	n/a	1-15

#### Notes:

- <sub>1</sub> All samples collected from 12-18 inches below ground surface.
- <sup>2</sup> First two digits of the sample number indicate the section from which they were collected.
- <sub>3</sub> MCA and off-site laboratory both analyzed for Bismuth-214. Samples were held before analysis so that Bismuth-214 was in equilibrium with Radium-226.
- <sup>4</sup> Sample results above the 3.0 pCi/g Ra-226 and 4.0 pCi/g Ra-226 (Section 33 NORM-affected area) Action Levels are shaded in gray. Where a sample has both an MCA and off-site laboratory result, the off-site laboratory result was used for all decisions, extent-of-contamination estimates, and calculations. Sample 33-23-2-31-180807 is located outside of NORM-affected area and is therefore compared to the 3.0 pCi/g Ra-226 Action Level.
- <sub>5</sub> n/a denotes that the sample was not sent for off-site laboratory analysis.



## **USEPA REGION 6**

### Table 1-4

# Soil Samples - TAL Metals Results Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Values in milligrams per kilogram (mg/kg)<sub>3</sub>

													is ber knobra	1 0, 0,3											
$Analyte_1$	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Nickel	Potassium	Silver	Sodium	Thallium	Mercury	Selenium	Vanadium	Zinc	Uranium	Figure Depicting Sample Location
Sample Number <sub>2</sub>																									1
32-01-31-181103-M	11,000	ND	3.3	150	0.56	ND	22,000	4.8	3.1	4.4	12,000	4.3	3,200	140	5	2,900	ND	180	ND	0.024	ND	16	24	ND	1-14
32-02-31-181103-M	25,000	ND	4.9	110	1.1	ND	6,000	12	6.3	10	22,000	6	4,800	220	9.7	4,500	ND	190	ND	0.019	ND	34	49	ND	1-14
32-03-31-181103-M	12,000	ND	3.2	150	0.66	ND	13,000	2.6	2.6	4.1	11,000	6.6	3,400	240	3.6	2,700	ND	140	ND	0.011	ND	23	17	77	1-14
32-03-32-181103-M	13,000	ND	4.3	250	0.72	ND	12,000	2.8	2.8	5.5	11,000	6.1	3,600	240	4	2,700	ND	140	ND	0.009	ND	15	14	ND	1-14
33-01-31-181103-M	8,300	ND	2.5	41	0.36	ND	2,800	1.7	1.8	2.7	8,700	3.9	2,100	76	2.7	1,600	ND	69	ND	0.019	12	23	11	ND	1-15
33-02-31-181103-M	22,000	ND	5.5	81	0.92	ND	7,800	11	6.2	11	24,000	7.3	4,600	170	13	4,200	ND	200	ND	0.018	2.8	30	50	ND	1-15
33-03-31-181103-M	25,000	ND	5.7	79	1.1	ND	6,400	14	6.5	12	26,000	6.8	5,200	180	14	5,300	ND	290	ND	0.017	3.2	37	54	24	1-15
33-04-31-181103-M	23,000	ND	6.3	70	1	ND	6,700	12	6.3	12	25,000	7.7	4,800	170	14	5,200	ND	180	ND	0.022	3.9	33	55	23	1-15
33-05-31-181103-M	22,000	ND	6.5	56	0.97	ND	5,700	12	8.6	11	26,000	8.4	4,000	160	14	4,400	ND	170	ND	0.023	ND	33	66	ND	1-15

Notes:

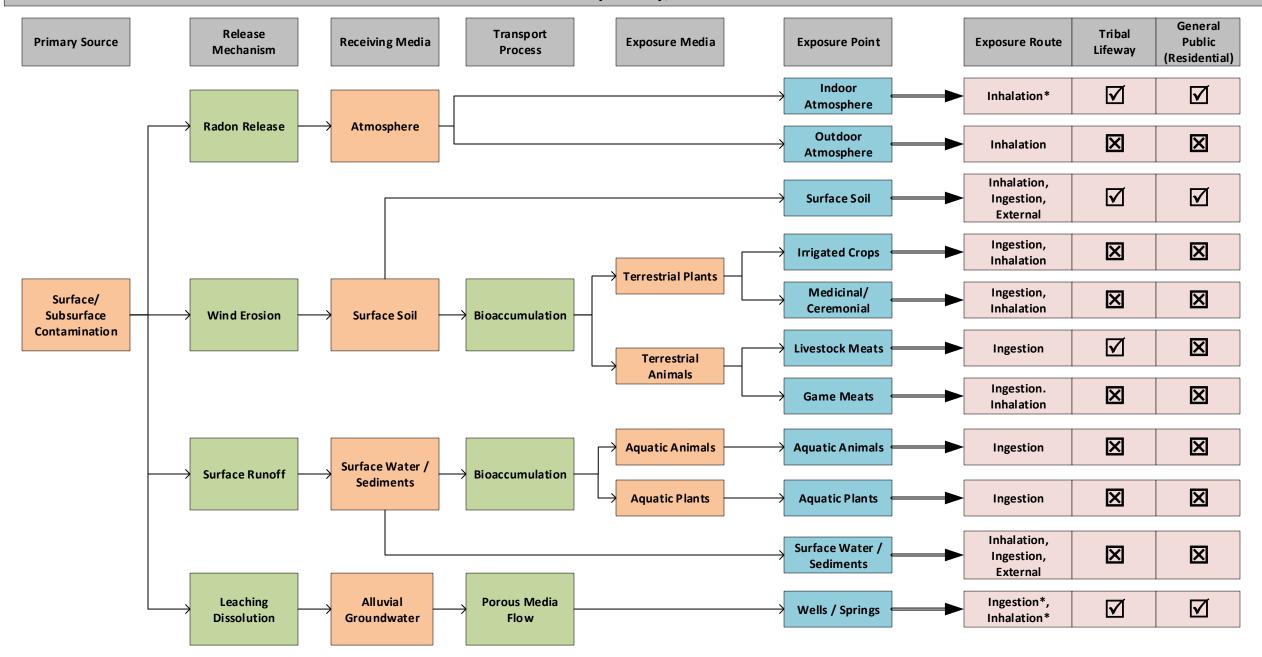


 $_{\rm 1}$  Analytes are from the EPA Target Analyte List plus Uranium.

 $_{
m 2}\,$  First two digits of the sample number are the section from which the sample was collected.

 $_{\rm 3}\,$  ND indicates that the analyte was not detected.

Table 2-1
Site-Specific Conceptual Site Model
Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site
McKinley County, New Mexico



<sup>\*</sup>The risks from radon inhalation in an indoor atmosphere and groundwater contamination are outside the scope of this EECA; they will be addressed using the methodology outlined in the report EPA Assessment of Risks from Radon in Homes (2003), and by the EPA Region 6 Remedial Section as part of a San Mateo Creek Basin groundwater investigation, respectively.

# Table 3-1 Chemical-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media	Requirement	Requirement Synopsis	Status and Rationale
Hazardous Wastes	Resource Conservation and Recovery Act (RCRA) of 1976, as amended –42 USC 6901 et seq.; 40 CFR 261 Subpart C	Provides for "cradle-to-grave" regulation of hazardous wastes. Per 42 USC 6903(27), RCRA does not regulate "source, special nuclear, or byproduct material" as defined in the Atomic Energy Act. Per 40 CFR 261.4(b)(7), wastes derived from the extraction, beneficiation and processing of ores are not hazardous wastes. U.S. EPA does not anticipate encountering RCRA hazardous wastes during this removal action. However, if hazardous wastes (e.g., buried drums containing solvents) are discovered, toxicity characteristic leaching procedure (TCLP) limits would be ARARs for characterizing hazardous waste.	Substantive requirements may be applicable if wastes that are subject to the Act are encountered.
Hazardous Materials	FEDERAL Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), as amended – And regulations at 40 CFR Part 192, Subparts A-E	Protect the public and the environment from uranium mill tailings. Some requirements (e.g., 40 CFR 192.02, 192.12, 192.32) may be ARARs.	TBC
Other	FEDERAL  Code of Federal Regulations (CFR), Title 10, Part 20  Nuclear Regulatory Commission (NRC) Regulations – Standards for Protection Against Radiation; Subpart D – Radiation Dose Limits	Establishes standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC.	Substantive requirements may be applicable or relevant and appropriate if source, byproduct, or special nuclear material is encountered.

# Table 3-1 (Continued) Chemical-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media	Requirement	Requirement Synopsis	Status and Rationale
Other	FEDERAL  EPA Directive on Protective Cleanup Levels for Radioactive Contamination at CERCLA sites. OSWER Directive 9200.4-18	Provides guidance for cleanup levels for CERCLA sites with radioactive contamination. Cleanup of radionuclides are governed by risk established in the NCP when ARARS are not available or sufficiently protective.	TBC.
Other	FEDERAL  EPA Directive on Conducting Risk Assessments for Radioactive Contamination at CERCLA sites.  OSWER Directive 9285.6-20	Provides guidance in a Q&A format, giving answers to several commonly asked questions regarding risk assessments at radioactively contaminated CERCLA sites.	TBC.
Hazardous Waste	STATE  20.4 New Mexico Administrative Code (NMAC) – Hazardous Waste Management	Establishes criteria for the classification of hazardous waste and for the treatment, storage, and disposal of hazardous waste. The state Act incorporates most Federal RCRA regulations, including the definition of solid waste, which excludes "source, byproduct or special nuclear material." New Mexico's definition of hazardous waste also excludes wastes from the extraction, beneficiation, and processing of ores and minerals. Although hazardous waste is not expected, the requirement to characterize waste to determine whether it is hazardous is an ARAR.	Substantive requirements may be applicable or relevant and appropriate if wastes that are subject to the Act are encountered.

# Table 3-1 (Continued) Chemical-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media	Requirement	Requirement Synopsis	Status and Rationale
Soil	STATE  Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico (New Mining and	Provides general guidance for cleanup and reclamation of existing uranium mine sites. Prepared by the New Mexico Mining and Minerals Division and the New Mexico Environment Department.	TBC – The numeric criteria listed in the guidance are not promulgated numeric standards but are recommended to satisfy NMAC 19.10 (New Mexico Mining Commission action-specific requirements).
	Minerals Division and the New Mexico Environment Department; March 2016)		(1) The concentration of Ra-226 in land averaged over any area of 100 square meters ("m²") shall not exceed the background level by more than (a) 5 pCi/g, averaged over the first 15 cm of soil below the surface, and (b) 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface.
			(2) Site post-reclamation radiation level ("PRRL") for gamma radiation should not exceed the site-specific value of gamma radiation that correlates to 5 pCi/g Ra-226 above background at the 95th percentile value.
			(3) For sites at which contaminated material exceeding the target radium activity level discussed above is emplaced in an on-site repository, cover material for the repository must achieve radon flux equal or less than 20 pCi/m²/s.
Water	STATE  20.6.2 NMAC – New Mexico Water Quality Ground and Surface Water Protections	Establishes water quality standards and regulations to prevent or abate water pollution from discharges.	Substantive requirements may be relevant and appropriate to surface runoff on tribal trust land, and may be applicable to surface runoff on non-tribal lands.



# Table 3-1 (Continued) Chemical-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media	Requirement	Requirement Synopsis	Status and Rationale
Water	STATE  20.6.4 NMAC – New Mexico Standards for Interstate and Intrastate Surface Waters	Establishes water quality standards that consist of the designated use or uses of surface waters, water quality criteria necessary to protect the use or uses, and an anti-degradation policy.	Substantive requirements may be relevant and appropriate to surface runoff on tribal lands, and may be applicable to surface runoff on non-tribal lands.
Other	STATE  20.3.4 NMAC – Standards for Protection Against Radiation	Establishes standards for protection against ionizing radiation resulting from activities conducted pursuant to licenses or registrations issued by the Department.	Substantive requirements may be relevant and appropriate.

#### Notes:

ARAR = applicable or relevant and appropriate requirements
CERCLA = Comprehensive Environmental Response Compensation and Liability Act
NCP = National Oil and Hazardous Substances Pollution Contingency Plan
pCi/g = pico Curies per gram

CFR = Code of Federal Regulations
NPL = National Priorities List
OSWER = Office of Solid Waste and Emergency Response
TBC = To Be Considered



# Table 3-2 Location-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media	Requirement	Requirement Synopsis	Status and Rationale
Cultural Resources	FEDERAL The Native American Graves Protection And Repatriation Act – 25 United States Code (USC) Section 3001 et seq and its regulations Title 43 CFR Part 10.	Protects Native American graves from desecration through the removal and trafficking of human remains and cultural items including funerary and sacred objects.	Substantive requirements applicable if Native American burials or cultural items are identified within area to be disturbed.
Cultural Resources	FEDERAL National Historic Preservation Act – 16 USC 470 et seq; 36 CFR Part 800	Provides for the protection of sites with historic places and structures.	Substantive requirements applicable if eligible resources identified within area to be disturbed.
Cultural Resources	FEDERAL Archeological Resources Protection Act of 1979 – 16 USC Sections 470aa-mm; 43 CFR Part 7	Prohibits removal of or damage to archaeological resources unless by permit or exception.	Substantive requirements applicable if eligible resources are identified within area to be disturbed.
Cultural Resources	FEDERAL American Indian Religious Freedom Act – 42 USC Section 1996 et seq.	Protects religious, ceremonial, and burial sites, and the free practice of religions by Native American groups.	Substantive requirements applicable if Native American sacred sites are identified within area to be disturbed.
Wildlife	FEDERAL Endangered Species Act – 16 USC Sections 1531-1544, Title 50 CFR Parts 17 and 402	Regulates the protection of threatened and endangered species or critical habitat of such species.	Substantive requirements applicable if protected species are identified within area to be disturbed.
Cultural Resources	STATE New Mexico Cultural Properties Act – New Mexico Statutes Annotated (NMSA) 1978 Sections 18-6-1 through 18-6-27	Requires the identification of cultural resources, assessment of impact on those resources that may be caused by the proposed remedy, and consultation with the State Historic Preservation Officer.	Substantive requirements applicable to response actions on non-tribal lands in New Mexico.

Notes:

ARAR = applicable or relevant and appropriate requirements

TBC = To Be Considered



# Table 3-3 Action-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media/ Activity	Requirement	Requirement Synopsis	Status and Rationale
Solid Wastes	FEDERAL  Resource Conservation and Recovery Act (RCRA) of 1976, as amended – 42 USC 6901 et seq.	Regulates disposal of solid waste. Per 42 USC 6903(27), RCRA does not regulate "source, special nuclear, or byproduct material" as defined in the Atomic Energy Act, but may apply to other wastes, including ores containing uranium in concentrations less than 500 ppm.	Substantive requirements may be applicable to wastes that are subject to the Act.
Solid Waste	FEDERAL  Criteria for Classification of Solid Waste Disposal Facilities – 40 CFR 257 and 258	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and, thereby, constitute prohibited open dumps.	Substantive requirements relevant and appropriate for siting disposal repositories.
Hazardous Materials	FEDERAL Federal Hazardous Materials Transportation Law (formerly Hazardous Materials Transportation Act) – 49 CFR Parts 171, 172, 173, 174	Provides protection against the risks to life, property, and the environment that are inherent in transportation of hazardous materials in commerce.	Substantive requirements applicable to transportation of materials subject to the Act, including radionuclides.
Water	FEDERAL  EPA Guidance for Developing Best Management Practices for Storm Water – Publication EPA/832/R-92006	Guidance for developing stormwater best management practices for industrial facilities.	TBC.
Water	FEDERAL  Clean Water Act (CWA) – Section 402, National Pollutant Discharge Elimination System (NPDES) Stormwater discharges (40 CFR parts 122, 125).	On-site and off-site discharges from site are required to meet the substantive CWA requirements, including discharge limitations, monitoring and best management practices.	Substantive requirements may be applicable.



# Table 3-3 (Continued) Action-Specific ARARs and TBC Information Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site

## **McKinley County, New Mexico**

Media/ Activity	Requirement	Requirement Synopsis	Status and Rationale
Water	FEDERAL  CWA – Section 404, dredged or fill material, 33 CFR Parts 320-330, 40 CFR 230.	Regulates discharge of dredge or fill material into waters of the U.S.	Substantive requirements may be applicable to activities impacting waters of the U.S.
Air	STATE  20.2 NMAC – Air Quality	Establishes ambient air quality standards, performance standards for specific sources of air pollutants, and specifies monitoring methods.	Substantive requirements may be relevant and appropriate to sources during removal action.
Mining	STATE  19.10 NMAC – Regulation of Non-Coal Mining	Establishes requirements for mine reclamation and close-out plans. The New Mexico Mining Act (NMMA), administered under NMMC Regulations, contemplates returning an area affected by mining activity to pre-mining conditions. The regulations apply to all currently-operating mines as well as to mines that operated for a minimum of two years between January 1, 1970 and June 18, 1993. Defines "reclamation" as the employment of measures to mitigate disturbance and stabilize the permit area so as to "minimize future impact" on the environment and to protect air and water quality [Section 69-36-3(K); 19.10.1.7(R)(1)]. Section 69-36-7.H.2 of the NMMA requires the "protection of human health and safety, the environment, wildlife and domestic animals." Also, sections 19.10.3.304.D.7.b, 19.10.5.507.B(2), 19.10.5.508.B and 19.10.6.603.C NMAC of the NMMC regulations have similar requirements. Section 69-36-11(B)(3) requires that existing sites be reclaimed so as to reestablish a self-sustaining ecosystem.	Substantive requirements are relevant and appropriate.



# Table 3-3 (Continued) Action-Specific ARARs and TBC Information

# Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Media/ Activity	Requirement	Requirement Synopsis	Status and Rationale
Wildlife	STATE  New Mexico Wildlife  Conservation Act – NMSA 178  Sections 17-2-37 thru 17-2-46	Provides for the protection of threatened and endangered species.	Substantive requirements may be applicable if protected species are identified within area to be disturbed.
Plants	STATE  New Mexico Endangered Plant  Species Act – NMSA 1978,  Section 75-6-1	Provides for the regulation and protection of threatened and endangered plant species. Endangered plant species means any plant species whose prospects of survival within the state are in jeopardy or are likely within the foreseeable future.	Substantive requirements may be applicable if protected species are identified within area to be disturbed.
Plants	STATE  New Mexico Endangered Plants  Regulations – Section 19.21 New  Mexico Administrative Code  (NMAC)	Establishes requirements for the protection of threatened and endangered flora and fauna.	Substantive requirements applicable if such species are identified within area to be disturbed.
Plants	STATE  New Mexico Noxious Weed  Control Act – NMSA 1978,  Sections 76-7-1 through 76-7-30	Addresses the management and control of noxious weeds because of their negative impact on the economy or the environment.	Relevant and appropriate requirement if noxious weed plant species that are not indigenous to New Mexico are found at the Site or within areas to be disturbed.

Notes:

ARAR = applicable or relevant and appropriate requirements

CFR = Code of Federal Regulations

CWA = Clean Water Act

EPA = U.S. Environmental Protection Agency

NMAC = New Mexico Administrative Code

NMSA = New Mexico Statutes Annotated

TBC = To Be Considered



Table 3-4
Off-Site Transportation and Disposal Cost Estimates
Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site
McKinley County, New Mexico

Disposal Facility	Location	One-way Distance (miles) <sup>1</sup>	Transportation Costs (\$/ton) <sup>2,3</sup>	Disposal/ Processing Costs (\$/ton) <sup>3,4</sup>	Total Costs (\$/ton) <sup>3,5</sup>
Clean Harbors	Deer Trail, CO	550	\$62.40	\$75.00	\$137.40
UC Foology	Beatty, NV	610			\$210.00
US Ecology	Grand View, ID	835			\$295.00

### Notes:

- 1) The haul distance is measured from the site to the disposal facility.
- 2) Transportation costs assume 40 highway-rated trucks per day carrying approximately 23 tons each. Includes one-time mobilization fee of \$1,290 per truck.
- 3) Budgetary quotes for disposal were received from US Ecology and Clean Harbors in December 2019.
- 4) The Clean Harbors disposal fee of \$75 per ton was used as the basis of the EE/CA cost estimate.
- 5) US Ecology total costs include transportation, processing and disposal costs.

# Table 4-1 Summary of Analysis of Alternatives Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

	Evaluation Criteria							
Removal Alternative	Protection of Human Health and the Environment	Compliance with ARARs	Short-Term Effectiveness	Long-Term Effectiveness and Permanence	Implementability	Cost Effectiveness		
Alternative1: No Further Action		Not Applicable	Low – No action.	Low – Does not provide any effectiveness or permanence.	Low – No action.	Low – No action.		
Alternative 2: Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility	High – Protection provided by waste being placed in an off- site engineered and regulated landfill facility.	High – Complies with ARARs.	Medium – Disturbance of the entire waste area during excavation. Effective once waste is removed from the Site.	High – No onsite waste to manage. Off site waste is managed at a permitted landfill facility permitted.	Medium – Readily implementable. Administratively and technically feasible.	Low		
Alternative 3: Consolidation and Capping of Contaminated Soil in Place	High – Protection provided by waste being consolidated on- site beneath an engineered cover. Ongoing maintenance required for protection.	High – Complies with ARARs.	High – Disturbance of the entire waste area during excavation and consolidation. Effective once cover system is in place.	Medium – Waste is managed beneath an engineered cover. Requires maintenance of the cover system.	High – Readily implementable. Administratively and technically feasible.	Medium		



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# Table 4-2 Estimated Risk of Fatalities and Greenhouse Gas Emissions Due to Off-Site Trucking Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

	Truckloads of Waste	Miles Round Trip to Transport Waste	Truckloads of Fill	Miles Round Trip to Transport Fill	Total Miles	Estimated Fatalities due to Off-Site Trucking <sup>1</sup>	Estimated Greenhouse Gas Emissions due to Off- Site Trucking (metric tons CO <sub>2</sub> e) <sup>2</sup>
Alternative 1, No Further Action	0	0	0	0	0	0.00	0
Alternative 2, Excavation and Off-Site Processing and Disposal of Contaminated Soils at Licensed Low-Level Radioactive Waste Facility (Clean Harbors, Deer Trail, CO)	7,300	1,100	4,500	40	8,210,000	0.13	14,573
Alternative 3, Consolidation and Capping of Contaminated Soil/Debris in Place	0	0	2,700	40	108,000	0.00	192

CO2e= Carbon Dioxide Equivalent

#### Notes:

1. A rate of 1.55 fatalities per 100 million large truck miles traveled was calculated as shown below using data (2014 - 2018) from the National Center for Statistics and Analysis. (2020, March). Large trucks: 2018 data. (Traffic Safety Facts. Report No. DOT HS 812 891). Washington, DC: National Highway Traffic Safety Administration (https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812891).

		People Killed in Crashes Involving Large Trucks	Large-Truck Miles Traveled (millions)		Fatality Rate per 100 Million Large-Truck Miles Traveled	(-
	2014	3,908		279,132		1.40
	2015	4,095		279,844		1.46
	2016	4,678		287,895		1.62
	2017	4,905		297,593		1.65
	2018	4,951		304,864		1.62
Average from 2014 - 2018: fatalities per 100 million miles traveled						1.55

2. Metric tons of CO2e per large truck mile traveled was calculated as shown below using data and methods from the EPA GHG Equivalencies Calculator - Calculations and References (https://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references). Carbon dioxide emissions per gallon of diesel fuel was obtained from the US Energy Information Administration Frequently Asked Questions (http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11).

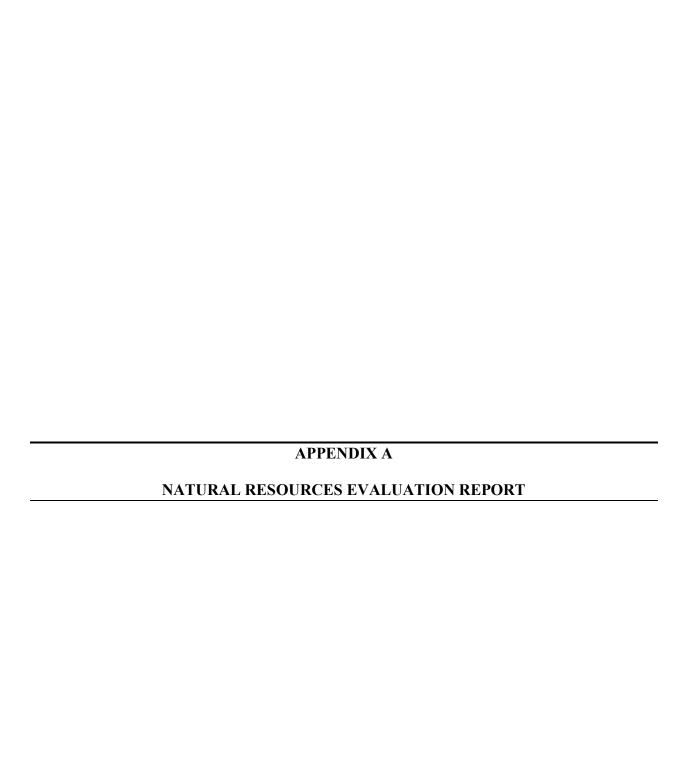
Mileage for Combination Trucks (Classification Types 8-13) was obtained from the FHWA Highway Statistics Table VM-1 based on 2012 and 2013 data (https://www.fhwa.dot.gov/policyinformation/statistics/2013/vm1.cfm).

22.38 lb CO2/gallon diesel fuel X	1 CO2e X	1 =	0.001775	metric tons CO2e	
2,205 lb CO2/metric ton CO2	0.986 CO2	5.8 miles/gallon		miles traveled	



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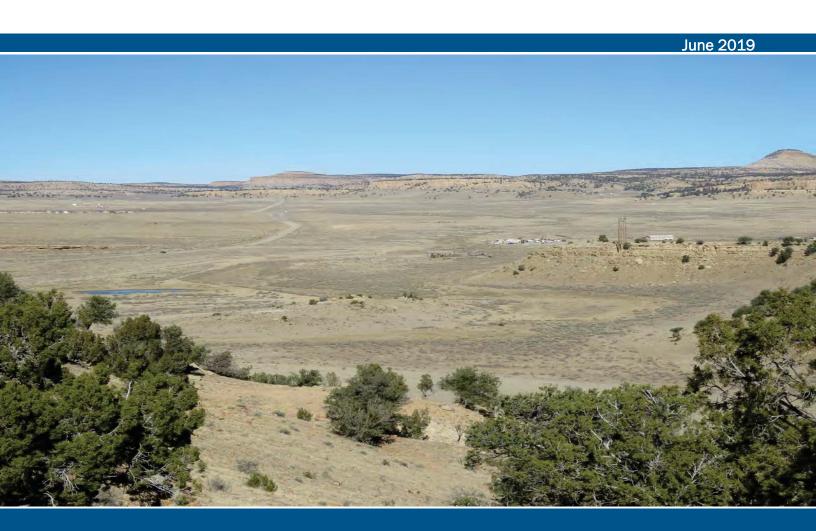




# **Natural Resources Evaluation**

Tronox NAUM Sections 32 & 33 McKinley County, New Mexico

Prepared For:
US Environmental Protection Agency Region 6
Weston Solutions





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#### INTRODUCTION

The US Environmental Protection Agency (USEPA) proposes to initiate mine waste removal on several former uranium mine sites to reestablish pre-mine habitats and promote restoration to a sustainable arid grassland ecology. The study area is located principally within the Ambrosia Lake Sub-District (ALSD) area of the Grants Mining District within McKinley County, New Mexico (Figure 1A in Appendix A). The reclamation study area consists of former underground uranium mines (the Section 32 and Section 33 mines) and associated lands and totals approximately 1,273 acres. It is located in Township 15 North, Range 11 West Sections 32 and 33 and appears on the *Thoreau NE, New Mexico* and *Goat Mountain* US Geological Survey 7.5-minute quadrangle maps (Figure 1B in Appendix A). The area is eligible for abatement activities subject to the Tronox Navajo Area Uranium Mine (NAUM) settlement, and this study area has been identified as the Tronox NAUM Section 32/33 Mine project area.

The Tronox NAUM Area comprises approximately 100 square miles within the ALSD in McKinley County, New Mexico. The ALSD is located within an area of uranium mineralization that extends approximately 100 miles long and 25 miles wide encompassing portions of McKinley, Cibola, Sandoval, and Bernalillo counties in New Mexico. The study area is located approximately 25 miles north/northwest of Grants and approximately 12 miles northeast of Thoreau, New Mexico (Figure 1C in Appendix A).

### **Proposed Action**

Former mine waste and excavated soils have been stockpiled and fenced off by EPA in Section 32. Section 33 has mine tailings and mine debris scattered within an exclosure. Scraped areas would be revegetated and recontoured to restore, to the extent feasible, pre-mining site conditions. Contaminated soils stockpiled in the study area surface could be removed and disposed of at an approved site outside of the study area.

### Methods

Existing site conditions as they pertain to natural resources relative to reclamation were characterized by obtaining field observational data, documented physical site properties, literature review information, and soil sampling results for the study area. Field work was completed in November of 2018, before the onset of winter weather, but after the migration of birds from the area.

In-field and desktop investigations were performed. Existing soil and watershed conditions were identified through a review of federal and state agency reports and webtools. Revegetation and site recommendations are tailored to site-specific conditions and based on recommendations from agricultural and reclamation sources from the vicinity.

Federal, State of New Mexico, and Navajo Nation listed and otherwise protected species were identified through agency database queries. A data request was requested from the Navajo Nation Heritage Program. Soil and vegetation samples were collected by Weston Solutions and select results provided for use in generating recommendations for this report.

Field surveys were performed to identify protected species, wildlife habitat, vegetative community types/percent cover, wildlife and cattle grazing values, invasive and noxious weeds, and water resources. Data were recorded on habitats for sensitive or protected species, vegetation diversity, potential biological receptors, grazing potential, vegetation height, palatable and non-palatable species, and potential watershed impacts.

Based on the initial size of 1,273 acres, NV5 identified 8 specific vegetation transect locations, and proposed 30-meter long vegetation transects at each of these locations to identify species and record coverage. Transect locations were initially widely spaced across the entire 1,273-acre project area. However, the area of surface disturbance was reduced, and most transects were repositioned to account for a smaller area of surface disturbance (approximatlely 40 acres) centered within the northern half of Section 32 extending into the northwest edge of Section 33, identified as the Casamero Lake Reclamation Area (See Figure 2, Appendix A). As a result of the relocation of transects, some of the vegetation communities (such as Plains Mesa Grassland) that occur only outside of the Casamero Lake Reclamation Area do not have transect data associated with them.

Vegetative cover along each of the 30-meter long transects was read at 1-centimeter intervals to generate a detailed estimate of cover by species within each community. Additionally, rangeland evaluation data was collected at each of the transects. Shrub density and height was collected by counting individual shrubs located within a 1-meter wide band centered on the vegetation transect. The height of each of these shrubs was also recorded. Production and stocking rate data was acquired from a 1-square-foot frame placed at locations spaced along the 30-meter long transects. All the current year's growth (both herbaceous stems and leaves and woody stems) that arose from within the frame was clipped to the ground level. Old leaves were discarded. The material was then bagged and weighed in the field with a digital scale. Simultaneously, Weston Solutions gathered soil samples and obtained vegetation clippings for chemical analysis.

Field surveys were performed to identify protected species, wildlife habitat, vegetative community types/percent cover, and water resources (waterways or ponding areas). A general walk over of the entire project area was completed. For the purposes of evaluating natural resources at the site, approximately 15 percent of the study area (190 acres) were subject to intensive ground surveys. This intensive ground survey included all the Casamero Lake Reclamation Area as well as representative samples of the other habitat types in the study area. Field surveys were conducted during late November 2018.

Individuals certified with, at a minimum, a 24-hour hazardous waste operations and emergency response (HAZWOPER) level of training entered the site. No respiratory personal protective equipment use was warranted based on low radioactivity levels present at the site.

### **EXISTING CONDITIONS/PRELIMINARY RECOMMENDATIONS**

### **Topography and Climate**

The study area occurs from approximately 7,002 to 7,336 feet in elevation above mean sea level and consists of mesas, bajadas, and braided ephemeral waterways.

Climate summaries for nearby Thoreau, New Mexico, indicate that the area is semiarid with a total average annual precipitation of 10.71 inches. Average monthly maximum temperatures range from 43.2 degrees Fahrenheit (°F) in January to 85.5°F in July. Average minimum monthly temperatures range from 18.6°F in January to 55.8°F in July with freezing being common from November through April. There is generally a pronounced peak in rainfall during the monsoon months from July to October (Western Regional Climate Summaries 2018).

### Soils/Soil Chemistry and Fertility

Soils at the study area identified by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS 2018) consisted of seven soil types. Table 1 presents each type within the project area.

Table 1 – Soil Types, Texture, and Abundance in the Project Area

SOIL TYPE	SOIL	TEXTURE	PERCENT PROJECT
	MAPUNIT		AREA
Penistaja-Tintero complex, 1 to	205	Sandy Loam and Clay Loam, Well-	19.7%
10 percent slopes		drained	
Sparank-San Mateo-Zia	230	Clay Loam and Loam	19.7%
'		Well Drained	
complex, 0 to 3 percent slopes			
Rock outcrop-Westmion-	290	Bedrock and Clay Loam	6.9%
Skyvillage complex, 30 to 80		Well Drained	
percent slopes			
Celavar-Atarque complex, 1 to	305	Loamy Soil	15.1%
8 percent slopes		Well Drained	
Zyme-Lockerby association, 5 to	338	Silty Clay and Channery Clay	7.8%
35 percent slopes		Well Drained	
Todest fine sandy loam, 2 to 8	376	Sandy Loam and Clay Loam	1.5%
percent slopes		Well Drained	
Berryhill-Casamero clays, 2 to	380	Clay to Silty Clay	29.3%
10 percent slopes		Well Drained	

The NRCS soil information was accessed for more detailed physical and chemical characteristics of area soils (Appendix B). The study area soils are expected to be comprised of clays, clay loams, or silty clay textures according to NRCS mapping. They are generally well drained; not hydric; moderately susceptible to wind and water erosion; and occur more than 200 feet from ground water depth. As indicated in the NRCS mapping, the soils observed on site were predominantly clay loams or clays.

Soil chemistry and fertility parameters were obtained via laboratory analysis of samples collected from the site (Weston 2018). Detailed results are provided in Appendix B. Surprisingly, the C:N ratios for all of the samples were high. None were less than 68:1 and three were over 1,000:1 (3,722:1, 2,385:1, and 1,801:1). The actual percent of total carbon in the soil was very homogenous among the samples ranging from 2.01–2.42%. Since this is total carbon value it is not clear how much of this is organic or inorganic. All three of the samples that had C:N ratios in excess of 1:1,000 had percent total nitrogen of 0.001% or less. The low nitrogen levels in these samples accounts for the inflated C:N ratios.

The composition of boron was low across all of the samples, and similarly phosphate and zinc were low across most of the samples. Other elements such as copper and manganese were normal, and potash and magnesium were high. Nitrogen varied between very low to high dependent on the sample, but in most of the samples with high C:N values the nitrate level was low. Sulfur varied widely ranging from very low to very high across the study area. Much like the carbon values, the pH levels across the study area were very similar ranging from 8.14–8.32. These are classified as alkaline soils but are not extreme.

#### Vegetation

The study area occurs within the Semiarid Tablelands ecoregion (Griffith et al. 2006). This ecoregion is characterized by dry plains, mesas, valleys, and canyons formed from sedimentary rocks. It supports arid and semi-arid grasslands, shrub/scrub zones, savannas, and woodlands.

According to Dick-Peddie (1993), the study area occurs primarily within Coniferous and Mixed Woodland. This fits the ground observations of the mesa tops and slopes but does not account for the shrub and grassland communities that dominate the lower elevations of the study area. The grasslands in the study area most closely resemble the Plains-Mesa Grassland community. The shrubby areas consisted of Great Basin Desert Shrub Saltbush communities. Arroyo Riparian vegetation is confined to the bottom of the ephemeral waterways that cross through the study area, but they constitute less than 2% of the overall area.

The dominant plant communities and associated species present at the study area are discussed in detail below. Six natural plant communities occurred in the study area consisting of a grassland community, two types of desert scrub, one type of savanna, a woodland, and arroyo riparian vegetation. All these plant communities were delineated and mapped (Figure 3, Appendix A). A listing for each community and their abundance in the study area is presented in Table 2. In addition to native plant communities there were also areas of open bedrock along the rims of the mesas that were nearly devoid of vegetation and are not included here as a vegetation type. There were also areas subject to considerable and persistent surface disturbance from human activities and no longer supported cohesive plant communities. Both the rimrock and disturbed areas are included in Table 1 only because in aggregate they account for 34 acres of the study area. In total, 90 species of plants representing 28 families were identified at the study area (Appendix C).

Table 2 – Area of Dominant Plant Communities and Associated Transects

COMMUNITY TYPE	SERIES: PRINCIPAL COMPONENT VEGETATION	~ ACRES	TRANSECTS
Plains-Mesa Grassland	Blue Grama/Galleta	352	None
Great Basin Desert Scrub	Saltbush/Blue Grama/Galleta/W. Wheat Grass	67	2, 3, 4
Great Basin Desert Scrub	Saltbush/Kochia/Gumweed/Various Weeds	575	5, 7
Juniper Savanna	One-seed Juniper/Galleta/Blue Grama	39	None
Coniferous Woodland	One-seed Juniper/Pinyon Pine/Bigelow Sage	180	1
Arroyo Riparian	Rabbitbrush/Saltbush/Galleta	25	6, 8
Disturbed	Areas functionally denuded by human activity	19	None
Bedrock	Exposed bedrock with scant plant cover	15	None

#### **Vegetation Overview**

Approximately 1,273 acres occurred within the initial survey area. Of this area, approximately 34 acres are estimated to be unvegetated. The unvegetated areas were occupied by rock-covered slopes, roads, disturbances around houses, or other human-made features. The study area consists of mesa tops, mesa slopes, bajada's, ephemeral riparian waterways, and associated floodplains.

Woodlands dominated the upper slopes and edges of the mesa habitats in the study area. Juniper Savanna occurred sporadically, mostly along the transition zone between woodland and grassland habitats on the lower slopes of the mesa and upper portions of the bajadas. Much of the area below the mesas consisted of gently sloping bajada's subtended by clay soils and dominated by Great Basin Desert Scrub Salt Bush

communities (Figure 3, Appendix A). Ephemeral waterways occurred throughout the study area, all draining ultimately in a westward direction. Arroyo riparian vegetation occurs within the channels and active floodplains of all ephemeral waterways within the study area. The vegetation within these drainages is co-dominated by a mixture of shrubs and grasses. Although widespread across the study area, these Arroyo Riparian communities account for a fraction of the total vegetation cover.

There were no natural ponds, but several man-made stock tanks were scattered across the study area. Some of these are wholly ephemeral and only contain water immediately after rain events. Others are larger and deeper with water persisting for weeks or months after precipitation events. But in all cases the grazing impacts of livestock on these facilities was such that there was no cohesive vegetation community remaining along the edges of the ponds or stock tanks.

Most of the 90 species of vascular plants noted in the study area were uncommon and in some cases were observed at only one or two locations. Overall plant diversity was very low across the site. Some of this may be due to very dry conditions during the spring and early summer of 2018 in the study area. In many cases common spring and summer herbaceous species expected in the area were completely absent and those present were extremely dwarfed.

Warm season grasses such as blue grama (Bouteloua gracilis), galleta (Pleuraphis jamesii), and alkali sacataon (Sporobolus airoides) dominate the grassland communities, but a substantial percentage of the overall cover of grasses consisted of cool season species such as western wheat grass (Pascopyrum smithii) and squirrel-tail (Elymus elymoides). Both the wheat grass and squirrel-tail were found scattered in the upland habitats in the study area and would likely do well in any future seeding effort in the area.

#### **Historical Photo Comparison**

Historical aerial photographs of the study area from 1973 and 1997 were compared with current study area conditions (Figure 3, Appendix A). There was very little substantive change in the vegetation composition from 1973 to the present. A few more houses have been added in Section 32 and the areas around them support more surface disturbance. The mine disturbance located in the extreme NW corner of Section 33 is more pronounced in the 1973 photo, but the distribution of Coniferous Woodland, Juniper Savanna, and Great Basin Desert Scrub Saltbush Series appears to be very similar. The Plains/Mesa Grassland habitats also appear to occupy the same extent as they currently do. In the 1997 photograph there was no evidence of past surface disturbance such as scraping or digging in Section 33. However, in the 1973 photo there were areas of parallel scrapes across the center of Section 33. It is uncertain if these were related to prospecting or mining activities in the area, but they are abundant enough and scattered over a large enough area that they may have contributed to the low plant species diversity noted in that portion of the study area.

Based on the density and extent of vegetation observed on the 1997 photographs, the historic waterway system appears to have been more heavily vegetated in the channel than was observed in either 1973 or 2018. The reduced cover in the drainage in 2018 may have been due to severe drought conditions that occurred in the area between 2008–2013. It is uncertain why the drainages appeared less vegetated in 1973.

#### **Vegetation Transects and Community Discussion**

As previously discussed, the placement of the eight transects used to collect vegetative coverage data were move from their original positions and concentrated in the northern portion of Section 32. As a

consequence some of the plant communities identified within the wider study area (such as Plains Mesa Grassland and Juniper Savanna) were not within the more concentrated study area (Table 2) and no transect data is available for them. However, these communities and their general vegetative structure will still be discussed.

An estimate of percent absolute cover was calculated for all species present within transects. The compiled data from each transect is provided in Appendix B. Table 3 presents a compilation of vegetative cover by the community types.

Some plant communities were so extensive that they intersected with multiple transects. In communities where multiple transects occurred, the data were combined in Table 3. The following is a detailed discussion of each community type found in the study area.

#### **Great Basin Desert Scrub**

Shrub communities dominate the Great Basin. Depending upon moisture, temperature, and soils, these communities can vary in composition. Within the study area, two Great Basin Desert Scrub communities were defined; both had a high percentage of four-wing saltbush present. The less abundant of these had grasses such as blue grama, galleta, and western wheat grass present (Great Basin Desert Scrub/Saltbush/Blue Grama/Galleta/Western Wheat Grass Series). The vegetative coverage within this community was locally quite high, averaging 50.21%. This community was scattered throughout the study area but usually in small patches. In total it covered only about 67 acres (Photo A).

The second of these was the most abundant community in the study area covering about 575 acres. It was dominated by four-wing saltbush but generally with low grass cover (usually 2–3%) (Great Basin Desert Scrub: Saltbush/Gumweed/Various Weeds). It supported a high percentage of weedy species such as summer cypress (*Kochia scoparia*), gumweed (*Grindelia nuda*), and dogweed (*Dyssodia papposa*) (Photo B). This community covers nearly all of the lowland habitats within the study area. In many areas grasses are almost absent and weedy species are abound. It appears to be more abundant on soils that had a higher percentage of clay within the soil structure. The vegetative coverage within this community was usually very low, sometimes less than 10% but averaging only about 14.35%. There are large areas dominated by four-wing saltbush with little to no herbaceous cover in between.

#### **Coniferous Woodland**

Coniferous Woodland covers the slopes and portions of the tops of all of the mesas found in the study area. It is the third most abundant plant community, covering 180 acres, within the study area. It occurs on the north and west slopes of most of the mesa's and lines the rims of the tops of the mesas. Very little of it occurs below the toe-slopes of the mesas in the study area. The dominant woody species within the community are pinyon (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*). Together these two species provide approximately 25% vegetative cover. The most common herbaceous species present was blue grama, which had about 8.26% vegetative cover (Photo C). This community type intergrades principally into the Plains/Mesa Grassland, which occurs in the central areas on top of the mesas within the overall study area. The woody vegetation structure within this community provides nesting habitat for a variety of migratory birds as well as habitat for large mammals such as mule deer (*Odocoileus hemionus*).

#### **Arroyo Riparian**

A series of ephemeral waterways, all tributaries of Casamero Draw, drain westward and southward through the study area. In many locations the flow within Casamero Draw, or its tributaries, can alternate

between well-defined channels with bed and bank to sheet flow areas with little or no channel evident. Human intervention has altered or curtailed the flows of these waterways. Berms have been installed across many segments of the arroyo system interrupting stormwater surges and collecting the runoff in stock ponds. Most of these are small and very ephemeral. However, at least three of these appear to hold water in the winter and after rain events in the summer. These are identified as ephemeral water sources in Figure 3, Appendix A. All three of these tanks appear to have persistent water, but because of cattle use there was literally no vegetation present adjacent to the water, and consequently no wetland. Approximately 25 acres of this Arroyo Riparian community type is spread out in linear form across the study area. The bulk of these arroyos (approximately 3 linear miles) occur in Section 32 where clearly defined channels are present. About a mile of poorly defined channel occurs in Section 33.

Two vegetation transects (6 and 8) recorded data from the Arroyo Riparian community type. The dominant vegetation within and adjacent to the active channels was consistent across all arroyo segments. The overall absolute vegetative coverage recorded between these two transects was 33.6% (Photo D). Usually it was dominated by four-wing saltbush, western wheat grass, gumweed, and the weedy summer cypress. These four species accounted for nearly 85% of the vegetative cover. Four-wing saltbush lined the upper edges of the channels and western wheat grass was often on sandy benches above the active channels. Summer cypress often grew right in the channel bottom and up onto the benches, but this annual can establish quickly and is often washed away by flood events. Blue grama was scattered and locally abundant along the tops of the banks of the drainages. One species that was also locally abundant but did not show up in the vegetation transects was rubber rabbitbrush (*Ericameria nauseosa*). This species occurred primarily along the more incised and defined portions of the arroyos located along the western edge of the study area in Section 32. It was not present along most of the smaller and shallow banked arroyos in the study area.

#### **Plains-Mesa Grassland**

Plains-Mesa Grassland was the second most abundant community type in the overall study area covering approximately 352 acres, but it did not occur in the Casamero Lake Reclamation Area and consequently no coverage transect data is available. However, past studies of other sites in the general area and detailed field observations during the general survey have provided adequate reference data to describe this community. This community was dominated by blue grama and galleta. Together these 2 grasses accounted for most of the vegetative cover (Photo E). Secondary grasses such spike dropseed (Sporobolus contractus) and ring muhly (Muhlenbergia torreyi) were present, and in areas of light surface disturbance various species of three-awn (Aristida sp.) were present. Subshrub associates were principally winterfat (Krascheninnikovia lanata), snakeweed (Gutierrezia sarothrae), and very widely scattered rubber rabbitbrush. Cacti such as prickly pear (Opuntia sp.) and cholla (Cylindropuntia sp.) species were scarce. Some areas of the community type, such as in the south-central portion of Section 32, were heavily grazed with a resulting decrease in species diversity. These areas were dominated principally by heavily cropped blue grama and more scattered galleta. Although these areas have low productivity, they do provide potential habitat for rare species such as mountain plover. Nearly all the Plains-Mesa Grassland occurred on shallow soils on tops of the mesa areas that occurred in the central and southern portions of Section 32 and the extreme northeast corner of Section 33.

#### Juniper Savanna

The Juniper Savanna community is limited to the western edge of the study area within Section 32. It is dominated by one-seed juniper and covers less than 5 acres of the study area. It had the lowest overall vegetative coverage (22.4 percent) of the communities. Grasses accounted for more than half of this cover and Junipers about 3.6 percent (Photo F). Although it occupies a small area relative to other communities,

it provides tree structure to the western half of the study area. Since it is outside of the area of Casamero Lake Reclamation Area we have no transect data for this community.

#### **Disclimax**

An area of approximately 19 acres located around active buildings and areas of past disturbance occurs in Section 32 within the northwest corner of the study area. Many of these locations are completely devoid of vegetation and others are dominated by the invasive annual weed summer cypress. This annual weed can choke out other vegetation leaving an unproductive habitat for wildlife. Since the overwhelming dominant within this area was an annual invasive weed, vegetation cover data was not collected and this was not treated as a community type.

Table 3 – Species/Approximate Percent Cover at Vegetation Transects

VEGETATION COMMUNITY AND SERIES	PLANT SPECIES	TRANSECTS	PERCENT COVER
Great Basin Desert Scrub –		2, 3, 4	
(Four-wing saltbush/Blue Grama/Galleta)			
	Amaranthus sp.		0.50
	Atriplex canescens		21.4
	Bouteloua gracilis		4.52
	Pleuraphis jamesii		19.59
	Pascopyrum smithii		1.42
	Ratibida tagetes		1.53
	Salsola tragus		0.56
	Verbesina encelioides		0.69
			Total: 50.21
	1		
Great Basin Desert Scrub – (Four-wing		5, 7	
Saltbush/Gumweed/Various Weeds)			
	Atriplex canescens		6.58
	Bouteloua gracilis	_	0.72
	Dyssodia papposa	_	0.18
	Grindelia nuda	_	2.88
	Kochia scoparia	_	1.92
	Pleuraphis jamesii	_	1.77
	Pascopyrum smithii		0.30
			Total: 14.35
Coniferous Woodland		1	
Connerous Woodiand	Bouteloua gracilis	⊣ <b>'</b> ⊢	8.26
	Juniperus monosperma	-	8.1
	Atriplex canescens	-	0.33
	Pinus edulis	-	16.26
	Pleuraphis jamesii	-	1.76
	Festuca octoflora		2.46
	restaca octojiora	-	Total: 37.2
Arroyo Riparian		6, 8	
	Amaranthus sp.		2.05
	Pascopyrum smithii		7.17

VEGETATION COMMUNITY AND SERIES	PLANT SPECIES	TRANSECTS	PERCENT COVER
	Grindelia nuda		4.43
	Atriplex canescens		9.70
	Salsola tragus		0.17
	Kochia scoparia		7.00
	Verbesina encelioides		0.30
	Bouteloua gracilis		1.85
	Rumex occidentalis		0.93
			Total: 33.60

#### Vegetation Height

Data were collected on the height of herbaceous and shrubby vegetation along each of the transects. Table 4 is a compilation of the height organized by vegetation class which included: grasses and herbs; shrubs and subshrubs; and trees that occur along each of the transects. These are identified by the dominant plant community in which they occur. The healthiest upland vegetation observed occurred within the Coniferous Woodland community (Transect 1) where the four-wing saltbush was on average nearly a meter in height and the grasses averaged nearly a 1/3 of a meter in height.

The most widespread community within the Casamero Lake Reclamation Area (Great Basin Desert Scrub (Four-wing Saltbush/Gumweed/Various Weeds) had the most poorly developed vegetation with four-wing saltbush averaging only 0.27 m in height. Conversely, the less abundant Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/Western Wheat Grass) community had woody vegetation averaging approximately 0.7 m in height and the grasses and herbs approximately 1/3 m tall.

Riparian vegetation along Transect 6 was well developed, with the average shrub height being close to a meter, and the average herbaceous vegetation being approximately 0.38 m. Throughout the study area vegetation height is low. The average shrub height is approximately 0.62 m and the average grass and herb height is approximately 0.27 m. A combination of heavy grazing and recent drought conditions appears to be the likely reason for the low height of the vegetation.

Table 4 – Average Vegetation Height along the Vegetation Transects

Transect	Community Type	Vegetation Height (M) Grasses and Herbs	Vegetation Height (M) (Shrubs/ Subshrub)	Vegetation Height (M) (Trees)
1	Coniferous Woodland (One-seed Juniper/Pinyon Pine/Bigelow Sage)	0.30m	0.88m	2.98m
2	Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/W. Wheat Grass)	0.25m	0.61m	NA
3	Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/W. Wheat Grass)	0.35m	0.73m	NA
4	Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/W. Wheat Grass)	0.21m	0.73m	NA
5	Great Basin Desert Scrub (Saltbush/Kochia/Gumweed/Various Weeds)	0.27m	0.52m	NA
6	Arroyo Riparian (Rabbitbrush/Saltbush/Galleta)	0.38m	0.97m	NA

7	Great Basin Desert Scrub (Saltbush/Kochia/Gumweed/Various Weeds)	0.27m	0.27m	NA
8	Arroyo Riparian (Rabbitbrush/Saltbush/Galleta)	0.12m	0.57m	NA

#### **Vegetation Discussion**

Although six native plant communities were documented in the study area, only three occurred within the Casamero Lake Reclamation Area where project activities are going to be concentrated. These are: Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/Western Wheat Grass); Great Basin Desert Scrub (Saltbush/Kochia/Gumweed/Various Weeds); and Arroyo Riparian (Rabbitbrush/Saltbush/Galleta). All of these are lowland communities that occur on mostly flat open ground. Most of Casamero Lake Reclamation Area has been heavily disturbed in the past and is still impacted by cattle grazing. As a result the overall vegetative cover and species diversity across much of this area is low. Transect 3 (located in the extreme NW corner of Section 33 in the Casamero Lake Reclamation area) was placed within an area that had been heavily disturbed by past mining activities, but also has been fenced for many years precluding cattle entrance and has revegetated on its own. We believe that the transect data for this location (Appendix B) provides a template of which species will do well in revegetation for the remainder of the Casamero Lake Reclamation Area. The overall coverage at Transect 3 was over 50%, with the dominant species being galleta, four-wing saltbush, blue grama, and western wheat grass. All of these species should be considered as primary components of seed mixes for future revegetation in the reclamation area. Based on the current plans the Coniferous Woodland, Juniper Savanna, and Plains-Mesa Grassland would be unaffected by the proposed project activities.

#### **New Mexico Noxious Weeds**

Noxious weeds are known to occur in the general area. However, we walked over most of the site and there were no State of New Mexico Class A,B or C weeds present.

To prevent establishment of weeds during the revegetation process, it is recommended that the contractor be required to wash all machinery prior to each site entry (if equipment is used at other sites during the reclamation process) and upon leaving the site to reduce likelihood of transporting seeds into and from the site. In addition, the application of mulch would reduce weedy species establishment.

#### Wildlife

#### Wildlife Overview

Several common species or their sign were observed within the study area. A list of species observed on site, as well as those expected to occur there based on other area surveys, is provided in Appendix C.

Ten species of mammals or their sign, including mule deer, Botta's pocket gopher (*Thamnomys bottae*), desert cottontail (*Sylvilagus audubonii*), banner-tailed kangaroo rat (*Dipodomys spectabilis*), Ord's kangaroo rat (*Dipodomys ordii*), Gunnison prairie dog (*Cynomys gunnisoni*), wood rat (*Neotoma sp.*), ground squirrel (*Ammospermophilus sp.*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*) were observed or identified by their sign. It is likely that bats roost within the cliff faces present nearby and hunt at stock ponds since the presence of water would support insects. Migratory Myotis (*Myotis sp.*) would be expected to roost in cliffs from March through October and would be active at the ponds at night. Many of the larger cliff faces in the study area were inspected during the general survey, but bat droppings were not present.

Only nine species of birds were observed, including residents such as roadrunner (*Geococcyx californianus*) and songbirds such as white-crowned sparrow (*Zonotrichia leucophrys*), dark-eyed junco (*Junco hyemalis*), horned lark (*Eremophila alpestris*), and house finch (*Haemorphous mexicanus*). Common raven (*Corvus corax*) and American crow (*Corvus brachyrhynchos*) were also present, as well as red-tailed hawk. Waterfowl were not observed, but several of the tanks in the area were filled with water and it is likely that during migration these tanks would provide stop over areas for migrating water fowl. Surveys were conducted during the winter and many other species of songbirds and raptors are likely present in the area during migration and nesting seasons.

Since surveys were conducted during the winter months, reptiles and amphibians were not active. However, based on past experience in the general areas there are a number of lizards, snakes, and potentially an amphibian which are likely to be present.

#### Wildlife Discussion

In general wildlife was not common across the study area with fewer than 20 vertebrate species being present, and many of these were noted from only a few observations (Appendix C). Based on the species list collected from other surveys in the general region, at least 50 vertebrates should be present within the study area. Overall birds were scarce, not only in species diversity, but in numbers. Large mammal sign (such as mule deer) was found only in the wooded areas around the periphery of the study area. Small mammals were also uncommon. Some of this lack of diversity and abundance is likely due to the time of the year (winter) when the surveys occurred. However, many of the lowland Great Basin Desert Scrub communities were in poor condition with stunted shrub growth and very little herbaceous ground cover. Additionally, a substantial portion of the north half of Section 32 is impacted by human activities and domestic predators such as dogs. All these factors can reduce the quality of habitat for vertebrate species.

#### **Birds**

Only nine species of birds were noted during the field surveys of the study area (Appendix C). Based on the topographic relief, and the abundance of woodland habitats along the eastern edge and southern boundary of the study area, birds should have been more abundant even in the winter months. Several jay species were expected in the wooded habitats in the study area, but none were seen. The only small birds regularly seen were white-crowned sparrow, house finch, and horned lark. The Great Basin Desert Scrub community that dominates most of the study area had particularly poor bird representation. In most areas the shrubs were low growing. In areas where the shrubs were taller, the adjacent ground cover is very low and depauperate in plant species diversity leaving little for ground feeding birds to eat.

Most birds observations occurred singularly; some of the corvids such as common raven and American crow were in small flocks. Resident species that would be expected in such habitat were either not present or very scarce.

Within the grassland habitats, the only bird species observed was horned lark, but during the breeding season other species such as vesper sparrow (*Pooecetes gramineus*) and western meadowlark (*Sturnella neglecta*) are expected.

During the breeding season the brushy portions of the study area should provide habitat for a variety of sparrows and other song birds including chipping sparrow (*Spizella passerine*), Brewer's sparrow (*Spizella breweri*), and dark-eyed junco, as well as the predatory loggerhead shrike (*Lanius Iudovicianus*).

There are several stock ponds in the study area that provide suitable habitat for migrating waterfowl. The only birds noted at these ponds during the surveys were horned larks, but during September and October species such as mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), northern shoveler (*Anas clypeata*), and northern pintail (*Anas acuta*) could be present.

#### Birds of Prey

The only bird of prey noted in the study area was red-tailed hawk (*Buteo jamaicensis*), and this species was confined principally to the eastern half of Section 33. However, a variety of other bird-of-prey species could occur within or near the study area. These are: northern harrier (*Circus cyaneus*), western burrowing owl (*Athene cunicularia*), American kestrel (*Falco sparverius*), and prairie falcon (*Falco mexicanus*). Golden eagle (*Aquila chrysaetos*) could occur in the general area but there is no suitable nesting habitat within the study area.

Western burrowing owls are a ground-dwelling species that usually occupy burrows created by mammals such as prairie dogs. During the nesting season, they can use several burrows, moving their young from burrow to burrow, as they mature. Although burrowing owls were not present, there were a few scattered prairie dog hole clusters in the center of Section 33 that could provide habitat for this species.

#### **Mammals**

Ten species of mammals were observed in the survey area and based on surveys of nearby areas, others would be expected. The larger mammals present included both herbivores and predators. Mule deer tracks and droppings were observed on top of the mesa in coniferous woodland along the eastern edge of the study area within Section 33. There were no other large ungulates present. Tracks and scat of both coyote and gray fox were found within the study area. Coyote sign was diffuse, but the gray fox sign was concentrated in the rocky areas along the edges of the mesas. Mountain lion (*Puma concolor*) and bobcat (*Lynx rufus*) are both likely to be in the general area but there was no sign of them during the site survey.

The presence of small burrowing mammals within the study area is important to the restoration process in that they provide the potential for soil mixing deep below the surface. Small mammals were generally scarce across the study area. Ord's kangaroo rat, which is normally a common species, was nearly absent in the study area. None were observed in the desert scrub communities and only scattered burrows were noted in the Plain-Mesa Grassland habitats. Similarly, Gunnison's prairie dog were very scarce. Only a few small colonies were noted in the center of Section 33 and none were noted in Section 32. The most common small mammal species observed was banner-tailed kangaroo rat. Banner-tailed kangaroo rats were scattered across the lower elevations of Section 33 and intermittent across the lower elevations of Section 32. Unlike many rodent species, banner-tailed kangaroo rats often maintain multiple granaries in the lower parts of the burrow systems. These granaries can have 2–8 pounds of grain stored in them. Their presence and the near absence of other small mammals may be the result of the availability of stored food sources available to this species. However, Ord's kangaroo rat can also maintain granaries and they were scarce at the site. Banner-tailed kangaroo rats have deep burrow systems and would probably not be taken during soil removal operations.

Botta's pocket gopher appeared sporadically in the study area, mostly in areas of looser soil. None were within the Casamero Lake Reclamation Area. Pocket gophers generally have shallow burrows, which are usually less than 1 meter deep and often much more shallow, and are generally only 5- to 35-centimeters

deep but can be upwards of 45 meters in length (Gano and States 1982). It is likely that most Botta's pocket gopher burrows would be taken by the soil removal process.

Desert cottontail were present but scarce. Old droppings were noted across much of the study area, but the only live rabbits observed occurred in the shrubby habitats along the larger arroyo systems in the study area. Their burrow systems are deep enough to be unaffected by the proposed soil removal. Those near the periphery of the study area are likely to move into adjacent vegetated habitats when surface clearing begins. During any future reclamation actions grain drops should be considered to provide food for small mammals until revegetation is fully established.

#### **Reptiles and Amphibians**

There were no amphibians or reptiles detected during the surveys. The field surveys were conducted during the cooler months when amphibians and reptiles are not likely to be active. Stock tanks were present in the study location and likely provide habitat for tiger salamanders (*Ambystoma mavortium*), Mexican spadefoot toads (*Spea multiplicata*), and western terrestrial garter snakes (*Thamnophis elegans*). Rock outcropping likely provides suitable habitat for plateau lizards (*Sceloporous tristichus*), collard lizards (*Crotaphytus collaris*), striped whipsnakes (*Coluber taeniatus*), prairie rattlesnakes (*Crotalus viridis*), and gopher snakes (*Pituophis cantifer*). Large open areas in the plains mesa grassland community likely provide ample habitat for lesser earless lizards (*Holbrookia maculata*), short horned lizards (*Phrynosoma hernandesi*), and plateau striped whiptails (*Aspidoscelis velox*). Suitable habitat was not present for any Navajo, State, or Federally protected species.

#### **Grazing/Rangeland Value**

The rangeland value analysis began with a review of NRCS data by soil type (Appendix B). Range production ratings are given in pounds per acre per year. Ratings are provided for a normal year, a favorable year, and an unfavorable year, respectively.

Four soil types comprise nearly 85% of the study area, and are the most significant in relation to rangeland analysis. The following summarize the NRCS estimated range production within each of these soils types on unfavorable (U), normal (N), and favorable (F) years. Data has also been included identifying which plant community each of these soil types is associated with.

The most common soil unit was Berryhill-Casamero clays, which was 2 to 10 percent slopes (soil unit: 380). It covered approximately 29.3% of the study area but is confined to Section 33 and only a small portion of it is Casamero Lake Reclamation Area. This soil type supported principally Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/W. Wheat Grass). The NRCS range production in pounds per acre is U-780, N-950, and F-1140.

Penistaja-Tintero complex, which was 1 to 10 percent slopes, is the second most common soil type covering approximately 19.7% of the study area. It occurs in direct association with the Plains-Mesa Grassland community. It was concentrated principally in the center part of Section 32 but occurs south of the Casamero Lake Reclamation Area. The NRCS range production in pounds per acre is U-465, N-810, and F-1155.

Sparank-San Mateo-Zia complex, which was 0 to 3 percent slopes, also covered approximately 19.7% of and underlies nearly all the Casamero Lake Reclamation Area and is likely to be most impacted by the

restoration process. This area was dominated by Great Basin Desert Scrub (Saltbush/Kochia/Gumweed/Various Weeds). The NRCS range production in pounds per acre is U-1058, N-2090, and F-3415.

Celavar-Atarque complex, which was 1 to 8 percent slopes, is the fourth most abundant soil in the study area covering approximately 15.1%. This soil type occurs principally at the edges of the mesa areas and was in direct association with the Coniferous Woodland community type. The NRCS range production in pounds per acre is U-248, N-425, and F-683.

Table 4 provides the actual recorded production from the vegetation transects within the study area. The Arroyo Riparian, Disturbed, and Bedrock communities were excluded as they comprise only a tiny portion of the study area. Additionally, the Plains-Mesa Grassland and Juniper Savanna communities were not included in the collection of the transect data. Neither of these communities occur within the Casamero Lake Reclamation Area and when the vegetation transects were redistributed into the sheet flow area, these communities were excluded.

Table 5 - Range Assessment Values for Vegetation Communities in the Study Area

COMMUNITY TYPE	~ACRES	RECORDED PRODUCTION (LBS./ACRE)	TOTAL AVAILABLE FORAGE
Great Basin Desert Scrub Saltbush/Blue			
Grama/Galleta/W. Wheat Grass	67	1,037	69,563
(Berryhill-Casamero clays, 2 to 10 percent slopes)			
Great Basin Desert Scrub			
Saltbush/Kochia/Gumweed/Various Weeds	575	67	38,525
(Sparank-San Mateo-Zia complex, 0 to 3 percent	5/5	67	
slopes)			
Coniferous Woodland	100	212	38,340
(Celavar-Atarque complex, 1 to 8 percent slopes)	180	213	

The Recorded Production of the Great Basin Desert Scrub (Saltbush/Blue Grama/Western Wheat Grass) community (1,037 lbs./acre), which is primarily underlain by Berryhill Casamero Clays, fits closely with the NRCS for range production. However, the Great Basin Desert (Saltbush/Kochia/Gumweed/Various Weeds) community that covers most of the Casamero Lake Reclamation Area supplies only a fraction (67 lbs./acre) of the NRCS Rangeland predicted productivity. This is likely the result of prior mine disturbance, heavy grazing pressure, and drought conditions in recent years. The overall vegetative cover in these areas averaged 14.3%, whereas transect data of other Great Basin Desert Shrub communities outside of these disturbed areas were around 50% vegetative cover.

Overall, grass coverage in the study area is lower than expected. Successful revegetation would be expected to increase the cover of grasses and herbs especially in the Great Basin Desert Scrub (Saltbush/Kochia/Gumweed/Various Weeds) community.

It is recommended that a five-year target composition and percent cover be identified to determine whether the effort is successful at meeting objectives. The site should be surveyed during the late summer (September) of the third year after planting to determine percent cover, species composition, and wildlife use as compared to the existing condition and to the objective condition.

Any deficiencies in meeting five-year objectives or alteration of five-year objectives could be identified at that time. This should be repeated after the five-year term in September as well. Range production should be estimated and evaluated during monitoring activities by a qualified range specialist to determine what level of grazing may be appropriate after objectives are met, or in keeping with any modified objectives.

#### Federal, Navajo, State Listed and Otherwise Protected Species

Federally listed and otherwise protected species were identified through a review of U.S. Fish and Wildlife Service (USFWS) and State of New Mexico agency lists (New Mexico Department of Game and Fish [NMDGF] and New Mexico Energy Mineral and Natural Resources Department [NMED] Forestry Division).

The USFWS maintains lists of federal endangered, threatened, proposed, and candidate species of plants and animals. It also administers the Migratory Bird Treaty Act and Bald and Golden Eagle Protection Act.

The Navajo Nation maintains a detailed list of Navajo Endangered Species (NESL) and provided detailed information on the habitat types, seasons, and conditions in which these species occur on Navajo lands. They also maintain a database of known occurrences and potential habitat for each of these species. The Navajo Nation also have their own laws protecting species such as bald and golden eagles. Prior to the onset of field operations for this project a data request was sent to the Navajo Heritage program and a response detailing their concerns for this study area was received (Appendix D).

The NMDGF maintains lists of state endangered and threatened animals. The NMED Forestry Division maintains a list of state endangered plant species (Appendix D).

#### Critical Habitat

No designated or proposed critical habitat occurs within the study area. The CP-2 unit of designated critical habitat for the Mexican spotted owl is located approximately 24 miles southeast of the study area within the Cibola National Forest (USFWS 2016b).

#### Listed or Otherwise Protected Species Eliminated from Further Analysis

The project would result in no effect/impact to the following eliminated species, for which no suitable habitat is present in the study area and none appears to be present within the action area (Table 5).

Table 6 – Protected Species Eliminated from Further Analysis

Group	Name	Status	Habitat	Rationale for Removal
Plants				
	Zuni fleabane (Erigeron rhizomatus)	USFWS E EMNRD E	Sparsely vegetated slopes in pinyon-juniper woodlands on Chinle/Baca formation soils	No suitable geologic substrate present
	Acoma Fleabane (Erigeron acomanus)	NESL G3	Sandy slopes and benches of Entrada sandstone formation	No suitable geologic substrate present
	Sivinski's Fleabane (Erigeron sivinskii)	NESL G4	Chinle shale in pinon-juniper woodland	No suitable geologic substrate present

	Navajo Bladderpod ( <i>Lesquerella navajoensis</i> )	NESL G3	Mesa rims of Todilto limestone	No suitable geologic substrate present
	Goodding's onion (Allium gooddingii)	EMNRD E	Forested slopes above 7,500 feet in elevation	Lacked forested habitat
	Parish's alkali grass (Puccinellia parishii)	EMNRD E	Alkaline seeps and wetlands	No alkali seeps or wetlands present
Fishes				
	Zuni blue-head sucker (Catostomus discobolus Yarrowi)	USFWS E NMDGF E	Perennial waterways in the Rio Nutria watershed	No perennial waterways present
Birds				
	Southwestern willow flycatcher (Empidonax traillii extimus)	USFWS E NMDGF E	Nests in dense willow and cottonwood riparian woodlands	No forested or shrubby riparian habitat present
	Mexican spotted owl (Strix occidentalis lucida)	USFWS T	Nests in old growth conifer habitat	No forest habitat present
	Yellow-billed cuckoo (Coccyzus americanus)	USFWS T NMDGF S	Nests in canopy cover of riparian woodlands	No forested or shrubby riparian habitat present
	Bald eagle (Haliaeetus leucocephalus alascanus)	BGEPA NMDGF T	Nests along large lakes and rivers, winters in riparian areas	No large lakes, rivers, or riparian habitats present
	Least tern (Sternula antillarum)	NMDGF E	Nest in depressions in sand or gravel bars near water	No large lakes, rivers, or playas present
	Costa's hummingbird (Calypte costae)	NMDGF T	Nests in Hidalgo County, rare as a vagrant in other parts of state	No suitable wooded canyons present

E – Endangered, T – Threatened, BGEPA – Bald and Golden Eagle Protection Act

#### <u>Listed or Otherwise Protected Species Evaluated Further</u>

Five species with Navajo or State status could potentially occur within the study area. There was no habitat for any Federal listed species. Species that may occur within the study area or immediately adjacent areas are evaluated further (Table 6).

Table 7 – Listed and Otherwise Protected Species with Potential to Occur at the Study Area

Group	Name	Status	Habitat
	Golden eagle (Aquila	BGEPA	Potential nesting habitat on cliff faces in S18 (T14N,
	chrysaetos)	NESL G3	R11W and T15N, R12W, S21) but none within 1 mile
			of the study area
	Burrowing owl	NESL G4	Potential habitat present in prairie dog holes, banner-
	(Athene cunicularia)		tailed kangaroo rat mounds, and mammals burrows
			in sidewalls of drainages
	Gray vireo (Vireo	NESL G4	Suitable nesting habitat in Coniferous Woodland
	vicinior)	NMDGF T	(Pinyon/Juniper woodlands) southern half of Section
			32 and eastern edge of Section 33

Group	Name	Status	Habitat
	Peregrine falcons	NESL G4	Potential nesting habitat on cliff faces in S18 (T14N,
	(Falco peregrinus	NMDGF T	R11W and T15N, R12W, S21) but none within 1 mile
	anatum/ tundrius)		of the study area
	Mountain plover	NESL G4	Potential habitat in Plains Mesa Grassland habitat in
	(Charadrius		the center of Section 32 south of the houses
	montanus)		
	Spotted bat	NMDGF T	Suitable nesting habitat in Coniferous Woodland
			(Pinyon/Juniper woodlands) southern half of Section
			32 and eastern edge of Section 33

T – Threatened, BGEPA – Bald and Golden Eagle Protection Act

#### Birds

**Golden eagle (Aquila chrysaetos)** – Golden eagles are protected under the Bald and Golden Eagle Protection Act from harm and harassment, and are also Navajo NESL Group 3 species and are protected under the Migratory Bird Treaty Act (MBTA). This is a very large bird of prey with a wingspan of up to 71 inches. Their breeding range extends throughout Canada and much of the western United States. They occur in open areas at lower to middle elevations throughout New Mexico. Preferred nesting sites are cavities within ledges and cliffs of mountainsides, mesa escarpments, and canyon walls.

The cliffs that golden eagles typically use are greater than 30 meters in height, although they can use cliffs of only 10 meters in height. The nesting cliffs are normally located directly adjacent to suitable foraging habitats. In New Mexico, this species begins courtship and nest construction as early as February.

There are several rock outcrops, mesas, and cliffs located within the vicinity of the study area, and this species is known to occur in the region. Small cliffs were found located both east and west of the study area. They are suitable for use by hawks, but none appeared high enough for golden eagle. Telescopic observations of cliffs within the vicinity were conducted to determine whether nests or sign were present. Several areas of whitewash on cliffs were observed but no nests. Suitable nesting habitat for golden eagle did occur in T14N, R11W, S18, about two miles south of the study area (Figure 5 Appendix A), and within T15N, R12W, S21 about two miles north of the study area (Photo G). There are no suitable nest sites within 1 mile of the study area. If present, golden eagles would be year round residents but none were observed during the field trips to the area.

Western burrowing owl (Athene cunicularia hypugaea) – This owl is protected under the Migratory Bird Treaty Act and is a Navajo Group 4 NESL species. It occurs on plains, treeless valleys, and mesas and prefers empty prairie dog or other rodent burrows that it can use for nesting and shelter, but can excavate its own burrows if needed. This species is found throughout the mid and lower elevations of New Mexico. It inhabits bare ground near areas such as golf courses and airports; open desert of yucca, cactus, and mesquite; and grassland-juniper habitats. Potential nesting habitat for this species occurs within the study area.

Prairie dogs were scarce within the study area, noted only within Section 33 outside of the Casamero Lake Reclamation Area. Banner-tailed kangaroo rats are widespread in the study area and many had burrows suitable for use by burrowing owl. All prairie dog holes and banner-tailed kangaroo rat burrows were examined. No burrowing owl sign was present.

Burrowing owls can move in and out of areas on an annual basis. If burrowing owls show up in the future the following measures are recommended to prevent direct impacts and reduce indirect impacts to this species.

Timing restrictions for vegetation clearing are recommended to avoid direct impacts to this species (avoid clearing during the general nest season of March 15 through September 30).

During the later summer prior to the onset of removal activities, a survey of all areas, which may support owl nests located within the final removal zone, should be completed. To the extent feasible, all occupied burrows (or clusters of burrows, likely used by a single pair) should be identified. Where a cluster of burrows that was occupied is removed, it is recommended that 2 artificial burrows be installed to offset the loss of nesting habitat in the area. Artificial burrows could be removed (outside nesting season) once the area is revegetated and supports prairie dogs again, potentially during final reclamation closeout activities.

**Gray vireo (Vireo vicinior)** – This is a state threatened bird, a Navajo Group 4 NESL species, and it is protected under the MBTA. It is found through much of the western United States and northern Mexico. It normally occurs in open rolling woodland, juniper savanna, and chaparral. It is found in arid lands, typically in pinyon-juniper habitat along steep or rolling slopes. This vireo is an insectivore. In New Mexico, it is found during the months of April through September when insects are most abundant.

Suitable nesting habitat for this species occurs within all of the woodland and savanna habitats in the study area (Photo H, Figure 4 Appendix A). This species has been documented north of Grants, NM, in previous studies we have completed; it also has been documented in the area by NM Department of Game and Fish (NMDGF, 2018). Since this species is known to occur in the vicinity it is possible that a territory could occur in the study area. There is no suitable habitat within the Casamero Lake Reclamation Area. If vegetation clearing is complete prior to the onset of the general migratory bird nest season (March 15 through September 30), individuals and nests would not be directly impacted.

However, potential indirect impacts associated with noise and activity during construction could not be avoided once excavation and planting begins if the species is nesting within approximately 0.25 miles of construction activity. It is recommended that species-specific surveys for gray vireo be conducted (male territorial calls played at intervals) during the nest season (May 15 to September 30) prior to the planned fall/winter clearing to determine whether the species is nesting within 0.25 miles of the reclamation site.

If it does, the proximity of territories relative to the proposed work area should be estimated. Work schedules can be sequenced in areas proximal to territories if needed to provide a buffer during the nest season. The NMDGF does not currently provide a required buffer distance for avoiding indirect impacts to this species, but the Navajo Nation recommends no activity within 1/8 miles of active nest sites during May 1 through August 31, and no habitat alteration within 1/8 miles of a known nest site year round. However, if the species is identified within the area, depending upon land ownership the NMDGF or Navajo Department of Game and Fish should be contacted regarding specific avoidance requirements.

Peregrine falcons (*Falco peregrinus anatum/tundrius*) — Peregrine falcons are protected as a State of New Mexico threatened species, a Navajo Group 4 NESL species, and it is protected under the MBTA. These subspecies breed south of the Arctic tundra region of North America, southward to Mexico. In New Mexico, they breed locally in mountainous areas and occur during migration and winter essentially statewide, though primarily in the eastern plains (NMDGF 2015). They summer and nest on tall, steep,

rocky cliffs associated with forest or woodland in close proximity to water. No suitable steep cliff habitat occurs within the study area but suitable nesting habitat for peregrine falcon did occur in T14N, R11W, and S18, about two miles south of the study area and within T15N, R12W, S21 about two miles north of the study area (Figure 5 Appendix A), but this is far enough away that even if they are present they should be unaffected by project activities.

**Mountain plover (***Charadrius montanus***)** is a Navajo Nation Group 4 species that is also protected under the MBTA. This species occurs in disturbed/grazed grasslands. Most of the project area is covered by Great Basin Desert Scrub but suitable grassland habitat for this species occurs within the Plains Mesa Grassland habitat on the top of the mesa within the center of Section 32 south of the housing area (Photo I). Within this area the grasses have been cropped by grazing and the area provides suitable nesting habitat for mountain plover. However, this habitat is far outside of the Casamero Lake Reclamation Area, and should be unaffected by project activities if present.

**Spotted bat (***Euderma maculatum***)** – Spotted bats are Bureau of Land Management (BLM) sensitive and protected as a threatened species by the State of New Mexico. This bat is a cliff dweller whose diurnal roosts are the cracks and crevices in cliffs, but are also known to roost in human-made structures. Small cliffs occur along the rims of the mesas in the study area (Photo J). This species may roost within these cliff habitats and could hunt above the stock ponds located in Section 32. Currently proposed activities are not anticipated to have any impact upon the potential bat roosting habitat along the edges of the mesa.

#### Migratory Birds

The Migratory Bird Treaty Act (16 United States Code [USC]. 703–712), as amended, protects migratory birds, their parts, eggs, and occupied nests from take, pursuit, import/export, hunting, and capture. A list of birds protected under the Act is available in Title 50 of the Code of Federal Regulations (CFR) Section 10.13.

Suitable nesting habitat for area tree and ground-nesting birds occurs within and adjacent to the study area. During the fall of 2018 surveys, no nests were found but there was suitable nesting habitat (aside from the disturbed areas) within every vegetative community in the study area.

It is recommended that vegetation clearing within the site be initiated and completed outside the general migratory bird nesting season for the area (March 15 to September 30) to prevent destruction of occupied nests.

There were no raptor nests present in any of the areas examined during field surveys, but there is the potential that species such as red-tailed hawks and great horned owls could nest in the cliffs along the mesa areas within the southern portion of Section 32. Raptors such as hawks and owls begin nesting earlier in the year (late January to early March), but are most likely to use woodlands and cliffs, which would not be impacted as part of this action. If it is necessary to clear vegetation during the nesting season, a preconstruction nest survey should be provided at least two weeks ahead of work to identify any occupied nests within the area. If occupied nests would be removed, a USFWS permit would be required first.

#### **Other Protected Species**

BLM maintains a list of sensitive species for lands it manages and evaluates proposed activities for consistency with the appropriate approved resource management plan. The New Mexico Heritage Program list of critically imperiled species (S1) was reviewed for informational purposes, as this is not a protected category.

#### **BLM Sensitive Species**

There are no BLM lands in the study area so BLM species have no jurisdiction, but are included as a reference of other species that agencies protect. Table 7 is a compilation of BLM species from the Farmington District. The only one that occurred in the project area was the Gunnison's prairie dog and they were restricted to a handful of burrows in the middle portion of Section 33. However, suitable habitat for pinyon jay occurred in the wooded portions of the study area, particularly in the southern half of Section 32. Potential habitat for Bendire's thrasher occurred within areas dominated by shrubs in the Great Basin Shrub community and into the woodland habitats.

Table 8 – BLM Sensitive Species Verified in the Farmington District

Group	Name	Habitat
Plants	Brack's fishhook cactus	Nacimiento formation soils in San
		Juan County
	Aztec gilia	Nacimiento formation soils in San
		Juan County
	San Juan milk weed	San Juan County
	Mancos saltbush	Mancos clay in San Juan County
Mammals	*Gunnison's prairie dog	Grasslands
	Spotted bat	Cliffs near open water
	Townsend's big eared bat	Caves, mine shafts
Birds	Yellow-billed cuckoo	Riparian woodlands
	Bald eagle	Nests near large water bodies
	Western burrowing owl	Grasslands/prairie dog burrows
	Southwestern willow flycatcher	Riparian woodlands
	Pinyon jay	Pinyon woodland/mixed conifer
	Bendire's thrasher	Desert canyons/scrub
Amphibians	Northern leopard frog	Wetland/spring/riparian
Fishes	Zuni blue head sucker	Aquatic, Rio Nutria area
	Flannelmouth sucker	Aquatic, San Juan Basin

<sup>\*</sup>Present in study area

#### New Mexico Heritage Critically Imperiled Species

New Mexico Heritage ranks native species into several categories. Heritage categories are not associated with a legal protective mechanism. Critically imperiled ranked species for McKinley County are provided in Table 8. Most are waterfowl that would be transients within the study area, if they were present.

Table 9 – New Mexico Heritage Critically Imperiled (S1) Species for McKinley County

Group	Name	Habitat
Birds	Ring-necked duck	Lacustrine/riparian
	Little blue heron	Lacustrine/riparian
	Bald eagle	Nests near large water bodies
	Least tern	Lacustrine/riparian
	Southwestern willow flycatcher	Riparian woodlands
	Marsh wren	Lacustrine/riparian
	Costa's hummingbird	Desert canyons/stream edges
Amphibians	Northern leopard frog	Wetland/spring/riparian
Fishes	Zuni blue head sucker	Aquatic, Rio Nutria area

#### Watershed

Watershed impacts resulting from uranium mining activities area are well documented, and identification and reclamation of legacy uranium mine surface and ground water quality are ongoing in the Ambrosia Lake Sub-District. No water quality analysis was completed for this report. The successful removal of uranium contaminated soils and revegetation of the site would be expected to reduce surface water contact with uranium, and improve water quality.

#### Waterways

Several Small arroyos that pass through study area do not support wetlands or a riparian corridor and appear to convey insufficient flows to justify augmentation. It is recommended that existing arroyos and swales remain unaltered during reclamation. Alteration is likely to result in sediment being transported to downstream areas and is not likely to result in improvement.

However, it is recommended that a hydrologic analysis be conducted prior to finalizing a revegetation plan to determine whether flows in local arroyos are sufficient to warrant extending them into large reclaimed grassland areas or implementing some other augmentation to improve the watershed.

Several stock pond features are present at the study area. One of these in Section 32 (Figure 4, Appendix A) carries sufficient flows to support wetland vegetation. It is recommended that stock pond features remain unscraped, as feasible, as they pool water for wildlife and plant use after storm events. Vegetation present around the pond could be augmented to provide improved riparian habitat and tree canopy for area birds. Tree shading would also reduce evaporation and improve growing conditions for plants. The increase in cover would improve wildlife habitat and reduce some evaporative loss if species not prone to high transpiration rates were used.

#### Wetlands

There are a number of water catchment features scattered across Sections 32 and 33. However, most of these have very limited watersheds and do not contain water long enough to support even facultative wetland plants. However, three of these tanks (listed as Ephemeral Water Sources on Figure 4 Appendix A) had substantial amounts of water present during the survey and historic aerial photography indicates they maintain a surface water presence over time. The largest of these is located in the west central portion of Section 32 at UTM Zone 13 E769244/N3931079 NAD 83. The surface water extent of this ponded area covers approximately 0.72 acres with approximately 652 linear feet of edge. During the 2018 survey we found that all vegetation along the edge of the pond had been removed by cattle use, and historic aerial photography indicates that this is the typical condition for this pond. The next largest pond

is located in the northwest corner of Section 33 at UTM Zone 13 E770784/N3931642 NAD 83. Its open water area covers approximately 0.25 acres with 384 linear feet of edge. Like the pond 1, it has water present on most years. Aerial photography showed that vegetation occurred along its edge in 2014, but since that time it has been devoid of vegetation (Photo K). Both of these ponds currently provide migratory waterfowl habitat but lack vegetation and consequently do not qualify technically as wetlands. If portions of them were fenced, they would likely support wetland vegetation. The third pond in the study area is a recent addition not appearing on aerial photography until 2009. It is located in the northwest corner of Section 32 at UTM Zone 13 E765529/N3931337 NAD 83. The open water area covers about 0.02 acres with about 130 feet of edge. Since it is in and amongst the housing area it was not visited during the survey, but aerial photograph indicates that it is fenced, and it is surrounded by dense vegetation. It may technically meet the criterial of wetland but is not connected to any waterway. All three of these ponds lie far outside of the Casamero Lake Reclamation Area and are unlikely to be impacted by project activities.

#### Watershed Impacts/Recommendations

Watershed impacts resulting from uranium mining activities area are well documented, and identification and reclamation of legacy uranium mine surface and ground water quality are ongoing in the Ambrosia Lake Sub-District. No water quality analysis was completed for this report. The successful removal of uranium contaminated soils and revegetation of the site would be expected to reduce surface water contact with uranium, and improve water quality.

Small arroyos that pass through study area do not support wetlands or a riparian corridor and appear to convey insufficient flows to justify augmentation. It is recommended that existing arroyos and swales remain unaltered during reclamation. Alteration is likely to result in sediment being transported to downstream areas and is not likely to result in improvement.

However, it is recommended that a hydrologic analysis be conducted prior to finalizing a revegetation plan to determine whether flows in local arroyos are sufficient to warrant extending them into large reclaimed grassland areas or implementing some other augmentation to improve the watershed.

There are a number of stock pond features present at the study area. It is recommended that these ponds remain unscraped and that the vegetation present around the ponds be augmented to provide improved riparian habitat and tree canopy for area birds.

#### **REVEGETATION/SOIL AMMEDMENT SUMMARY**

The revegetation strategy of the removal area, once identified, will be based on an ecological approach that would attempt to restore shrub and grassland conditions to sustain native animal and plant communities and enhance wildlife use of the area.

A Draft Revegetation Plan for the proposed removal area will be prepared prior to the identification of the final removal area for review by cooperating agencies. The following summarizes the elements expected to be addressed in the Draft Revegetation Plan.

#### **Revegetation and Seed Mix Recommendations**

Information used to develop the revegetation strategy will be obtained from the following sources:

- 1. Historic aerial photographs that predate the uranium mining activities within the study area will be reviewed as well as the data compiled in this report.
- 2. Additional ground surveys will be conducted. Vegetation-covered transects will be identified and surveyed to provide reference sites documenting the dominant perennial vegetation composition and cover within the plant communities located in the revegetation area.
- 3. Survey findings from nearby areas will be reviewed and un-mined adjacent habitats will be surveyed briefly for comparison, if authorization for entry is obtained.
- 4. Data from previous and ongoing mining and reclamation actions in the area will be reviewed

The recommended seed mix and application rate will be determined based on the updated location of the removal area. However, based upon the data recovered during the 2018 surveys we found that most of the revegetation area supports similar vegetation and believe that seed mixtures composed of grasses such as galleta, blue grama, and western wheat grass, and shrubs such as four-wing saltbush, and possibly winterfat should be considered as primary components in revegetation seed mixes.

Recommendations for planting of cover crops, mulching, watering, and amending soils, as well as special planting recommendations for pond areas will also be provided.

Recommendations for amending soils are expected to address the following soil issues: carbon/nitrogen ratio, texture, and water holding capacity.

The addition of organic soil amendments such as sawdust, bark, compost, and manure; as well as the addition of humate, and their potential application rates at the site will be addressed.

#### **SUMMARY OF RECOMMENDATIONS**

The following summarizes measures that are recommended to preserve existing resources/features or improve the study area. Other measures directly related to reclamation activities will be provided in a draft revegetation plan for the removal zone.

- Avoid cliffs and slopes located within the general study area, which provide bird nesting and bat roosting habitat. These are concentrated primarily in the southern half of Section 32, the northwestern corner of Section 32, and the eastern edge of Section 33. None of these locations falls within the Casamero Lake Reclamation Area.
- Avoid juniper and pinyon pine trees when removing vegetation. These occur in the southern half
  of Section 32 and the eastern edge of Section 33. None of the woodland communities occur in the
  Casamero Lake Reclamation Area.
- Clear vegetation during the fall and winter months outside the general nesting season for migratory birds.

- Provide a species-specific survey for gray vireo and mountain plover to determine whether they occur within the area.
- At least three stock tanks in the area hold surface water for extended periods and may have enough moisture present to support the establishment of riparian trees such as cottonwood or willow. First, avoid impacts to the ponds. Second, evaluate if small portions of these ponds could be fenced from cattle access and potentially create small enclaves of wooded habitat around the ponded areas.
- During current and future reclamation actions provide relocation or grain drops to allow small mammals to become re-established while the seeded vegetation becomes established.
- After any future reclamation actions provide removal site monitoring during September at 3 and 5 years post planting to compare observations with project objectives relative to plant species composition, percent cover, wildlife use, and range production.

#### **PHOTOS**



Photo A – Great Basin Desert Scrub (Saltbush/Blue Grama/Galleta/W. Wheat Grass)



Photo B – Great Basin Desert Scrub (Saltbush/Kochia/ Gumweed/Various Weeds)



Photo C – Coniferous Woodland



Photo D – Arroyo riparian



Photo E – Plains Mesa Grassland



Photo F – Juniper Savanna



Photo G – Potential Golden Eagle Habitat



Photo H – Potential Gray Vireo Habitat



Photo I – Potential Mountain Plover Habitat



Photo J – Potential Spotted Bat Habitat



Photo K – Ponded Water Area

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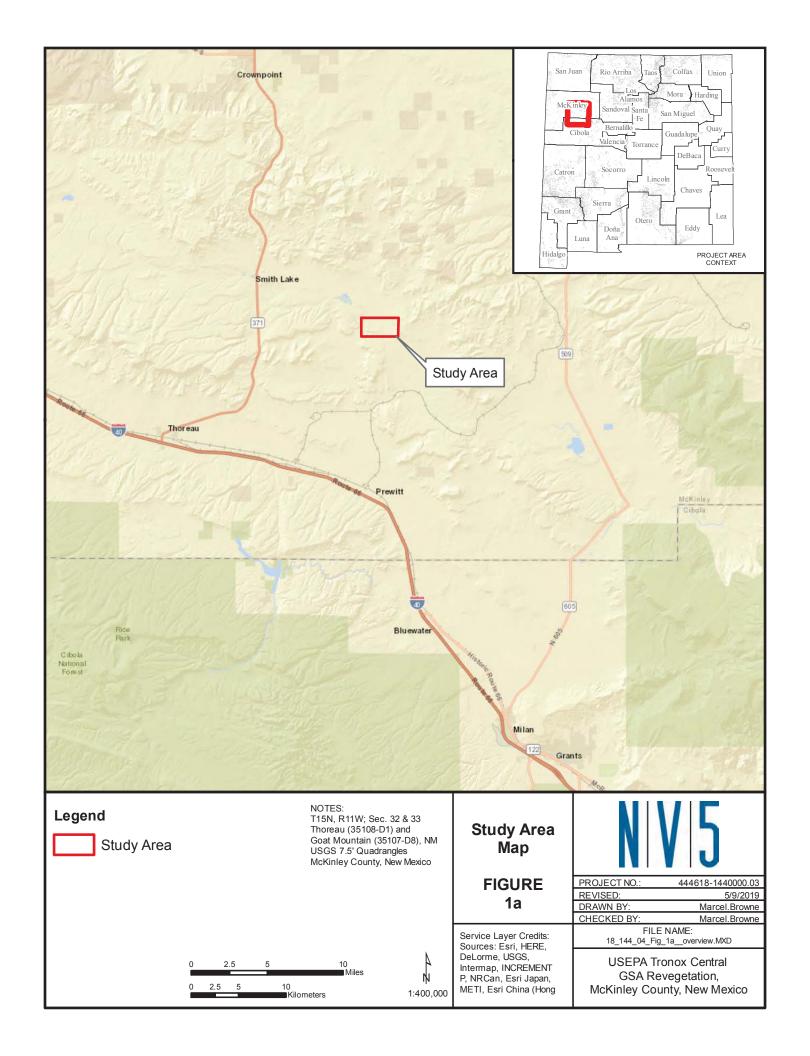
Western Regional Climate Center

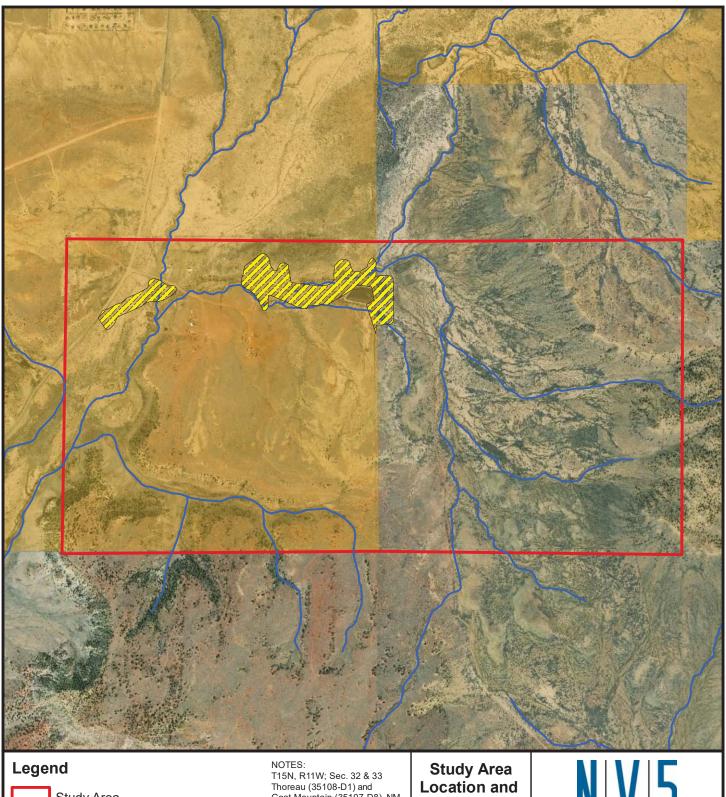
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#### **APPENDIX A**

Figures 1a-5







Study Area



Casamero Reclamation Area

#### **Land Ownership**



Navajo

Private

0.25 0.125 Kilometers

T15N, R11W; Sec. 32 & 33 Thoreau (35108-D1) and Goat Mountain (35107-D8), NM USGS 7.5' Quadrangles

### **Ownership** McKinley County, New Mexico

1:24,000

#### **FIGURE** 1b

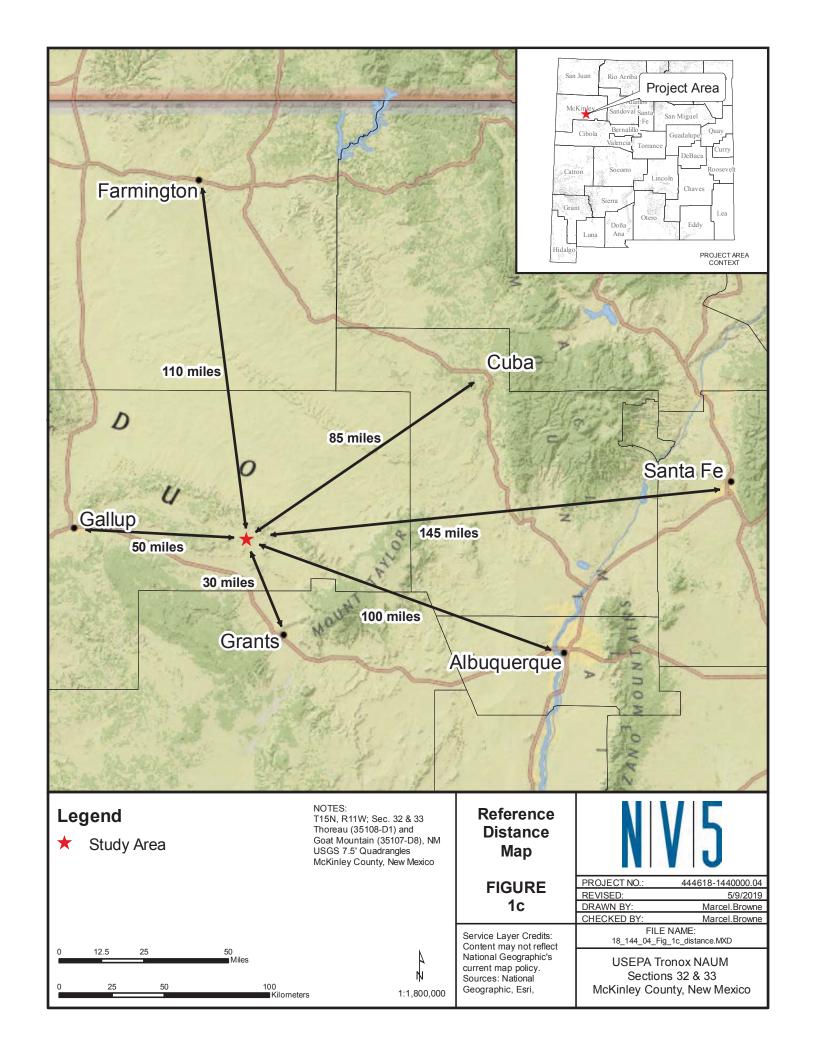
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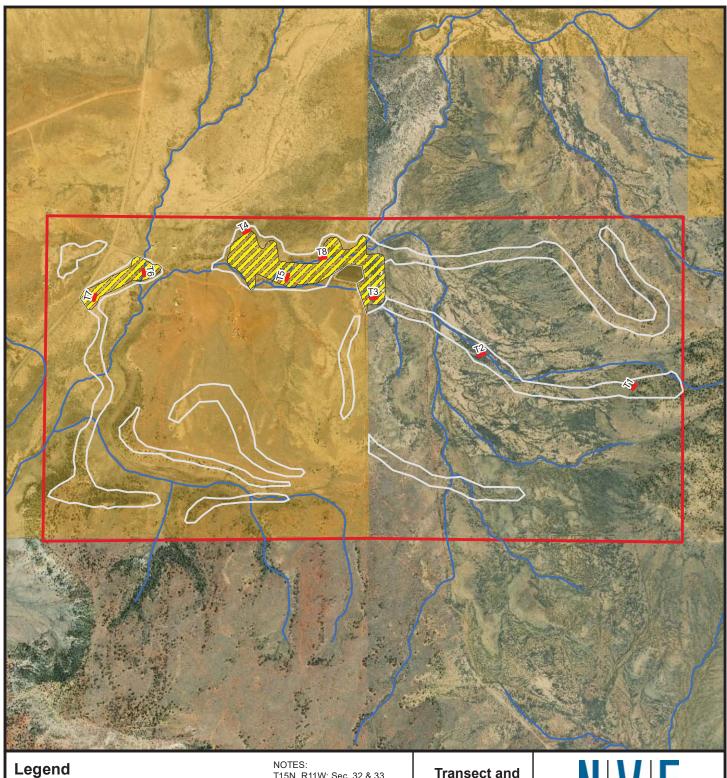
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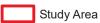
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REVISED:	6/27/2019
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CHECKED BY:	Marcel.Browne
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USEPA Tronox NAUM Sections 32 & 33 McKinley County, New Mexico







Casamero Reclamation Area

Intensive Survey Area

Transects

#### **Land Ownership**

Navajo Private



T15N, R11W; Sec. 32 & 33 Thoreau (35108-D1) and Goat Mountain (35107-D8), NM USGS 7.5' Quadrangles McKinley County, New Mexico

#### **Transect and Intensive Survey** Area Locations

1:23,247

#### **FIGURE** 2

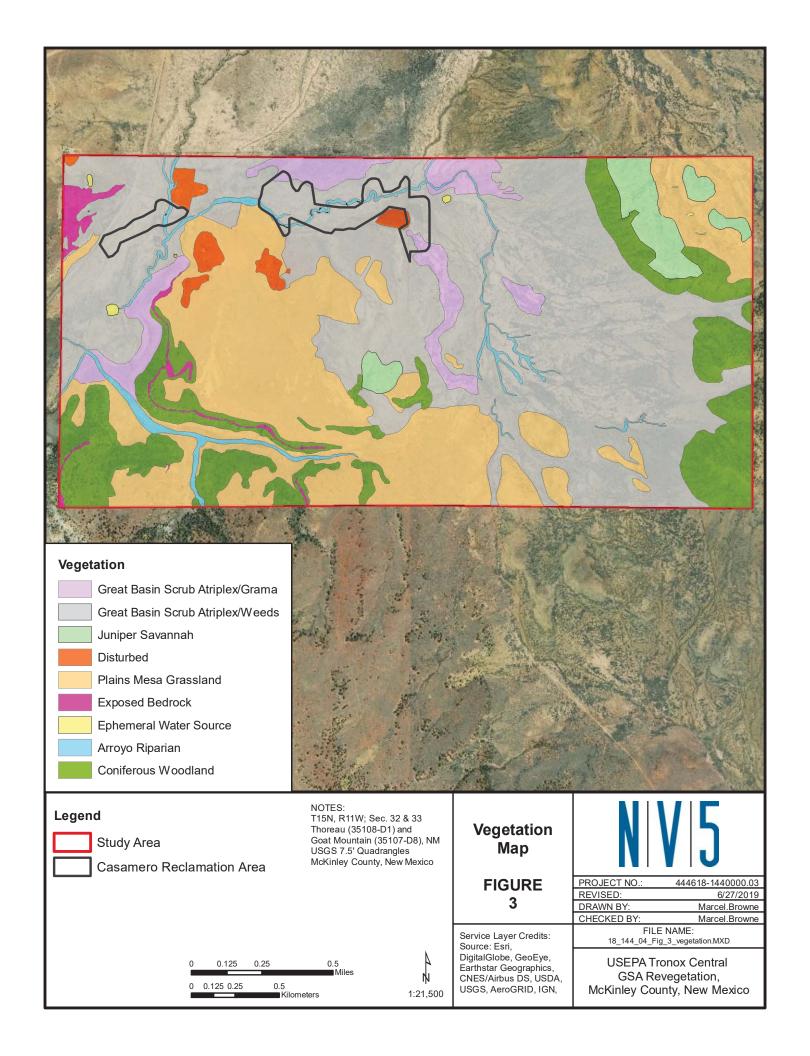
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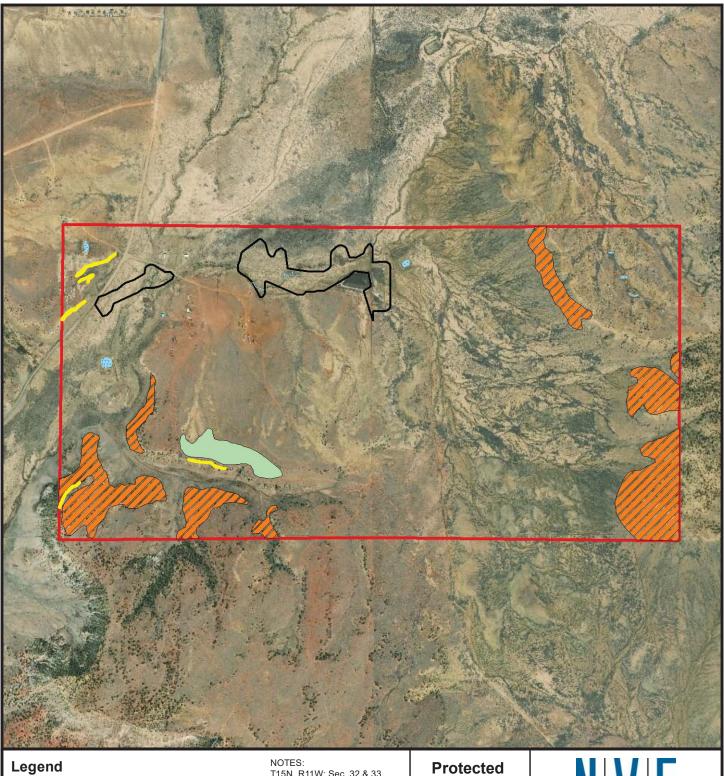
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DRAWN BY:	Marcel.Browne
CHECKED BY:	Marcel.Browne

FILE NAME: 18\_144\_04\_Fig\_2\_transects.MXD

**USEPA Tronox NAUM** Sections 32 & 33 McKinley County, New Mexico







Casamero Reclamation Area



Gray Vireo Potential Habitat



Mountain Plover Habitat



Spotted Bat Potential Habitat



Ephemeral Water Source



NOTES: T15N, R11W; Sec. 32 & 33 Thoreau (35108-D1) and Goat Mountain (35107-D8), NM USGS 7.5' Quadrangles McKinley County, New Mexico

County, New Mexico FIGU

1:24,000

### FIGURE 4

**Species** 

Habitat

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN,

### NV5

 PROJECT NO.:
 444618-1440000.04

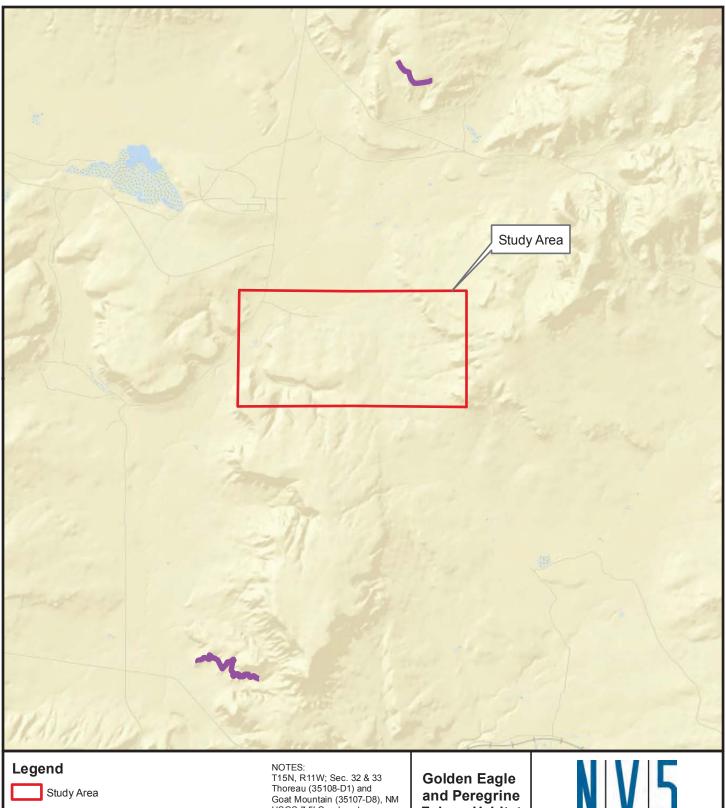
 REVISED:
 6/27/2019

 DRAWN BY:
 Marcel.Browne

 CHECKED BY:
 Marcel.Browne

FILE NAME: 18\_144\_04\_Fig\_4\_resource.MXD

USEPA Tronox NAUM Sections 32 & 33 McKinley County, New Mexico



Golden Eagle and Peregrine Falcon Habitat

USGS 7.5' Quadrangles McKinley County, New Mexico

#### 0.25 0.5 Kilometers

#### 1:65,000

### **Falcon Habitat**

#### **FIGURE** 5

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong

### NV5

PROJECT NO.:	444618-1440000.03
REVISED:	5/9/2019
DRAWN BY:	Marcel.Browne
CHECKED BY:	Marcel.Browne

FILE NAME: 18\_144\_04\_Fig\_5\_raptors.MXD

**USEPA Tronox Central** GSA Revegetation, McKinley County, New Mexico

#### **APPENDIX B**

Soil Characteristics

Soil and Plant Sampling Results

**Vegetation Sampling Results** 

Vegetation Transect Tables

11/19/2018 Page 1 of 3

# MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map

Source of Map: Natural Resources Conservation Service measurements.

Coordinate System: Web Mercator (EPSG:3857)

Web Soil Survey URL:

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

Streams and Canals

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

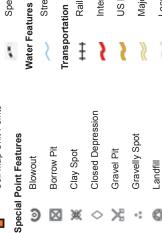
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

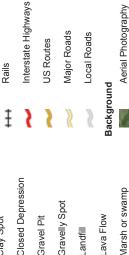
Date(s) aerial images were photographed: Feb 19, 2016—Oct

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.



Soils







Miscellaneous Water

Mine or Quarry

Lava Flow

Perennial Water

Rock Outcrop



Severely Eroded Spot

Sinkhole

Sandy Spot Saline Spot



USDA

#### **Map Unit Legend**

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI	
205	Penistaja-Tintero complex, 1 to 10 percent slopes	248.8	19.6%	
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	246.9	19.4%	
290	Rock outcrop-Westmion- Skyvillage complex, 30 to 80 percent slopes	91.2	7.2%	
305	Celavar-Atarque complex, 1 to 8 percent slopes	195.7	15.4%	
338	Zyme-Lockerby association, 5 to 35 percent slopes	92.7	7.3%	
376	Todest fine sandy loam, 2 to 8 percent slopes	18.2	1.4%	
380	Berryhill-Casamero clays, 2 to 10 percent slopes	378.4	29.8%	
Totals for Area of Interest		1,271.8	100.0%	

35° 29' 49" N



USDA

35° 28' 28" N

#### **Depth to Any Soil Restrictive Layer**

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	>200	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	>200	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	0	91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	79	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	38	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	61	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	>200	378.4	29.8%
Totals for Area of Inter	rest		1,271.8	100.0%

#### **Description**

A "restrictive layer" is a nearly continuous layer that has one or more physical, chemical, or thermal properties that significantly impede the movement of water and air through the soil or that restrict roots or otherwise provide an unfavorable root environment. Examples are bedrock, cemented layers, dense layers, and frozen layers.

This theme presents the depth to any type of restrictive layer that is described for each map unit. If more than one type of restrictive layer is described for an individual soil type, the depth to the shallowest one is presented. If no restrictive layer is described in a map unit, it is represented by the "> 200" depth class.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

#### **Rating Options**

Units of Measure: centimeters

Aggregation Method: Dominant Component Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No

35° 29' 49" N

108° 2' 18" W

35° 28' 28" N

108° 2' 18" W

#### K Factor, Whole Soil

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	.24	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	.37	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes		91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	.32	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	.37	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	.28	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	.24	378.4	29.8%
Totals for Area of Inter	rest	1,271.8	100.0%	

#### **Description**

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

#### Rating Options

Aggregation Method: Dominant Condition Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

108° 2' 18" W

35° 29' 49" N

108° 2' 18" W

35° 28' 28" N

Web Soil Survey National Cooperative Soil Survey

#### Wind Erodibility Index

		<b>-</b>		
Map unit symbol	Map unit name	Rating (tons per acre per year)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	86	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	86	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes		91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	56	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	48	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	86	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	86	378.4	29.8%
Totals for Area of Inter	rest		1,271.8	100.0%

#### **Description**

The wind erodibility index is a numerical value indicating the susceptibility of soil to wind erosion, or the tons per acre per year that can be expected to be lost to wind erosion. There is a close correlation between wind erosion and the texture of the surface layer, the size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. Soil moisture and frozen soil layers also influence wind erosion.

#### **Rating Options**

Units of Measure: tons per acre per year Aggregation Method: Dominant Condition Component Percent Cutoff: None Specified

Tie-break Rule: Higher

#### Soil Health - Organic Matter

Organic matter percent is the weight of decomposed plant, animal, and microbial residues exclusive of non-decomposed plant and animal residues. It is expressed as a percentage, by weight, of the soil material that is less than 2 mm in diameter.

#### Significance

Soil organic matter (SOM) influences the physical, chemical, and biological properties of soils far more than suggested by its relatively small proportion in most soils. The organic fraction influences plant growth through its influence on these soil properties. It encourages soil aggregation, especially macroaggregation, increases porosity, and lowers bulk density. Because the soil structure is improved, water infiltration rates increase. SOM has a high capacity to adsorb and exchange cations and is important to pesticide binding. It furnishes energy to microorganisms in the soil. As SOM is decomposed by soil microbes, it releases nitrogen, phosphorous, sulfur, and many micronutrients, which become available for plant growth. SOM is a heterogeneous, dynamic substance that varies in particle size, carbon content, decomposition rate, and turnover time. In general, the content of SOM is highest at the surface—where plant, animal, and microbial residue inputs are greatest—and decreases with depth.

Total organic carbon (TOC) is the carbon (C) stored in SOM. Total organic carbon is also referred to as soil organic carbon (SOC) in the scientific literature. Organic carbon enters the soil through the decomposition of plant and animal residues, root exudates, and living and dead microorganisms. Inorganic carbon is common in calcareous soils in the form of calcium and magnesium carbonates. In calcareous soils, the content of inorganic carbon can exceed TOC.

#### Factors Affecting Content of SOM and SOC

Inherent factors - Soil texture, parent material, drainage, climate, and time affect accumulation of SOM. Soils that are rich in clay have greater capacity to protect SOM from decomposition by stabilizing substances that bind to clay surfaces. The formation of soil aggregates—enabled by the presence of clay, aluminum and iron oxides, fungal hyphae, bacterial exudates (carbohydrates), and fine roots—protects SOM from microbial decomposition. Extractable aluminum and allophanes, which are present in volcanic soils, can react with SOM to form compounds that are stable and resist microbial decomposition. Warm temperatures increase decomposition rates of SOM. High mean annual precipitation increases accumulation rates of SOM by stimulating the production of plant biomass.

Loss of SOM through erosion results in SOM variations along slope gradients. Areas of level topography tend to have much more SOM than areas with other slope classes. Both elevation and topographic gradients affect local climate, vegetation distribution, and soil properties. They also affect associated biogeochemical processes, including SOM dynamics. Analysis of factors affecting C in the conterminous United States indicates that the effects of land use, topography (elevation and slope), and mean annual precipitation on SOM are more obvious than the effects of mean annual temperature. However, when other variables are highly restricted, SOM content clearly declines with increasing temperature.

Dynamic factors - Dynamic gains and losses in SOM are due primarily to management decisions in combination with climate and microbial influences. Accumulation of SOM is controlled by the rate of C mineralization, the amount and stage of decomposition of plant residues, and the addition of organic amendments to soil.

Soil organic carbon comprises approximately 52 to 58% of the SOM and is the main source of energy for soil microorganisms. The C within plant residues, particulate organic matter, and soil microbial biomass is generally considered to be within the active pool of SOM (table 1). The emergent view of SOM focuses on microbial access to SOM and includes an emphasis on the need to manage C flows rather than discrete C pools. During decomposition of SOM, energy and nutrients are released and utilized by plant roots and soil biota. Recognizing that SOM is a continuum of decomposition products is a first step in designing management strategies for renewing SOM sources throughout the year.

Table 1-Soil Organic Matter Pools

Soil organic matter fraction	Particle size	Description
Soil microbial biomass	Variable	The living pool of soil organic matter, particularly bacteria and fungi
Plant residues	>= 2.0 mm	Recognizable plant shoots and roots
Particulate organic matter	0.06 to 2 mm	Partially decomposed plant material, hyphae, seeds, etc.
Biochemically stable organic matter		The ultimate stage of decomposition, dominated by stable compounds

Soil aggregates of various sizes and stabilities can act as sites at which SOM is physically protected from decomposition and C mineralization. Soil disturbance and aggregate destruction increase biodegradation of SOM. Aggregates are readily broken apart by tillage operations.

Crop residues incorporated into or left on the soil surface reduce erosion and the losses of SOM associated with sediment. In acidic soils, applications of lime increase plant productivity, microbial activity, organic matter decomposition, and CO<sub>2</sub> release.

The diversity of the soil microbial population affects SOM. For example, while soil bacteria and some fungi participate in SOM loss by mineralizing C compounds, other fungi, such as mycorrhizae, facilitate stabilization and physical protection by aggregating SOM with clay and minerals. SOM is better protected from degradation within aggregates than in free-form.

#### Relationship to Soil Function

SOM is one of the most important soil constituents. It affects plant growth by improving aggregate stability, soil structure, water availability, and nutrient cycling. SOM fractions in the active pool, described above, are the main source of energy and nutrients for soil microorganisms, which mediate nutrient cycling in the soil. Biochemically stable SOM participates in aggregate stability and in holding capacity for nutrients and water.

Microaggregates are formed by mineral interactions with iron and aluminum oxides and are generally considered an inherent soil characteristic. They are, however, impacted by current and past management. Fine roots, fungal hyphae, and organic carbon compounds, such as complex sugars (carbohydrates) and proteins (also referred to as glues), bind mineral particles and microaggregates together to form macroaggregates that are still porous enough to allow air, water, and plant roots to move through the soil.

An increase in SOM leads to greater biological diversity and activity in the soil, thus increasing biological control of plant diseases and pests.

#### Problems Associated with Low Organic Matter Levels

Low levels of SOM result in energy-source shortages and thereby lowered levels of microbial biomass, activity, and nutrient mineralization. In noncalcareous soils, aggregate stability, infiltration, drainage, and airflow are also reduced. Scarcity of SOM results in less diversity in soil biota and a risk of disruption to the food chain equilibrium. This disruption can cause disturbance in the soil environment (e.g., increased plant pests and diseases and accumulation of toxic substances).

#### Improving SOM Levels

An estimated 4.4x10<sup>9</sup> tons of C have been lost from soils of the United States due to traditional farming practices. Most of this carbon was SOC. Nearly half of the SOM has been lost from many agricultural soils. Other farming practices, such as no-till and cover cropping (especially when used together), can stop losses of SOM and even lead to increases. Continuous application of manure and compost can increase SOM. Burning, harvesting, or otherwise removing plant residues decreases SOM.

#### Measurement

SOM is measured in the laboratory by determining total carbon (TC) content using either dry or wet-dry combustion. Current analytical methods do not distinguish between decomposed and nondecomposed residues, so soil is first sieved to 2 mm to remove as much of the recognizable plant material as possible. If no carbonates are present, TC is considered to be the same as TOC (or SOC). For calcareous soils, soil inorganic carbon in the form carbonates must also be measured and then subtracted from the TC to determine TOC content. Results are given as the percent TOC in dry soil. To convert percent TOC to percent SOM, multiply the TOC percentage by 1.724. To convert percent SOM to percent TOC, divide the SOM percentage by 1.724. Note that this value continues to be debated by researchers with possible values ranging from 1.4 to 2.5 (Pribyl, 2010). A conversion factor of 2 has been suggested for this database but has not yet been adopted. Detailed procedures for measurement of SOM are outlined in "Soil Survey Investigations Report No. 42, Kellogg Soil Survey Laboratory Methods Manual, Version 5.0," (Soil Survey Staff, 2014).

Many soil testing laboratories use a "loss on ignition" method to estimate soil organic matter. The estimate produced by this method must be correlated to analytical TOC measurements for each area to improve accuracy. The loss on ignition method can provide a good indication of the trend in SOM content within a field. It is important to note that temperature and timing used for the loss on ignition approach vary across labs and can influence results. Thus, comparisons should be made using only results from within a given lab.

Many soil testing laboratories use a "loss on ignition" method to estimate soil organic matter. The estimate produced by this method must be correlated to analytical TOC measurements for each area to improve accuracy. The loss on ignition method can provide a good indication of the trend in SOM content within a field. It is important to note that temperature and timing used for the loss on ignition approach vary across labs and can influence results. Thus, comparisons should be made using only results from within a given lab.

Currently, no standard method exists to measure TOC in the field. Attempts have been made to develop charts that match color to TOC content, but the correlation is better within soil landscapes and only for limited soils. Near-infrared spectroscopy has been tested for measuring C directly in the field, but it is expensive and sensitive to moisture content.

#### **Estimates**

Color and feel are soil characteristics that can be used to estimate SOM content. Color comparisons in areas of similar parent materials and textures can be correlated with laboratory data and thereby enable a soil scientist to make field estimates. In general, darker colors or black indicate the presence of higher amounts of organic matter. The contrast of color between the A horizon and subsurface horizons is also a good indicator. Sandy soils tend to look darker with a lower content of SOM. In general, lower numbers for hue, value, and chroma (in the Munsell soil color system) tend to be associated with darker soil colors that are attributed to higher content of SOM, soil moisture, or both.

#### References

United States Department of Agriculture, Natural Resources Conservation Service, National soil survey handbook, title 430-VI. (http://soils.usda.gov)

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Sikora, L.J., and D.E. Stott. 1996. Soil organic carbon and nitrogen. In: J.W. Doran and A.J. Jones, editors, Methods for assessing soil quality. Madison, WI. p. 157–167.

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Soil Survey Staff, 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (ed.), U.S. Department of Agriculture, Natural Resources Conservation Service.

#### Report—Soil Health - Organic Matter

Map symbol and soil name	Pct. of map unit	Horizon Name	Depth (inches)	Organic matter low (Pct)	Organic matter RV (Pct)	Organic matter high (Pct)
205—Penistaja-Tintero complex, 1 to 10 percent slopes						
Penistaja	45	А	0-3	1.0	1.5	2.0
		Bt	3-19	0.5	0.8	1.0
		Bk	19-65	0.5	0.8	1.0
Tintero	40	A	0-4	0.5	0.8	1.0
		Bt	4-16	0.5	0.8	1.0
		Bk1	16-48	0.5	0.8	1.0
		Bk2	48-65	0.5	0.8	1.0
230—Sparank-San Mateo- Zia complex, 0 to 3 percent slopes						
Sparank	40	Α	0-2	1.0	1.5	2.0
		C1	2-25	0.5	0.8	1.0
		C2	25-65	0.5	0.8	1.0
San mateo	35	A	0-2	1.0	1.5	2.0
		C1	2-15	0.5	0.8	1.0
		C2	15-30	0.5	0.8	1.0
		С3	30-39	0.5	0.8	1.0
		C4	39-45	0.5	0.8	1.0
		C5	45-65	0.5	0.8	1.0
Zia	20	Α	0-3	1.0	1.5	2.0
		Bw	3-12	0.5	0.8	1.0
		2C1	12-20	0.5	0.8	1.0
		2C2	20-28	0.5	0.8	1.0
		2C3	28-70	0.5	0.8	1.0
290—Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes						
Rock outcrop	45	R	0-60	-	<u> </u>	
Westmion	30	A	0-2	0.5	0.8	1.0
vvestillori		2C	2-14	0.2	0.4	0.6
Harris Market Company		2Cr	14-20	-	_	-
Skyvillage	15	А	0-2	0.5	0.8	1.0
		С	2-13	0.2	0.4	0.6
		R	13-20	_	-	_

Map symbol and soil	Pct. of map	Horizon	Depth	Organic matter	Organic matter	Organic matter
name	unit	Name	(inches)	low (Pct)	RV (Pct)	high (Pct)
305—Celavar-Atarque complex, 1 to 8 percent slopes		1				
Celavar	50	A	0-2	0.5	0.8	1.0
		Bt1	2-24	0.1	0.3	0.5
		Bt2	24-31	0.1	0.3	0.5
		2R	31-40	_	-	_
Atarque	35	А	0-3	0.5	0.8	1.0
		Bt	3-14	0.5	0.7	0.9
		2R	14-20	_		-
338—Zyme-Lockerby association, 5 to 35 percent slopes						
Zyme	50	Α	0-3	0.5	0.8	1.0
Zyme		Cky1	3-8	0.0	0.3	0.5
		Cky2	8-15	0.0	0.3	0.5
		Cr	15-20	-	-	_
Lockerby	40	A	0-1	1.0	1.5	2.0
		Bw	1-11	0.5	0.8	1.0
		Bss	11-15	0.0	0.3	0.5
		Bssy	15-26	0.0	0.3	0.5
		Cr	26-40			_
376—Todest fine sandy loam, 2 to 8 percent slopes						
Todest	80	Α	0-1	0.5	0.7	0.9
		Btk1	1-8	0.1	0.3	0.5
		Btk2	8-14	0.1	0.3	0.5
		Bk	14-24	0,1	0.3	0.5
		R	24-40	_	_	_

Map symbol and soil name	Pct. of map unit	Horizon Name	Depth (inches)	Organic matter low (Pct)	Organic matter RV (Pct)	Organic matter high (Pct)
380—Berryhill-Casamero clays, 2 to 10 percent slopes						
Berryhill	50	Α	0-2	0.5	0.8	1,0
		Bw	2-12	0.5	0.8	1.0
		Bssyz1	12-26	0.5	0.8	1.0
		Bssyz2	26-39	0.2	0.3	0.5
		Bssyz3	39-70	0.2	0.3	0.5
Casamero	45	A	0-3	0.5	0.8	1.0
		Bss	3-11	0.5	0.5	0.5
		Bssyz	11-18	0.5	0.5	0.5
		Cr	18-20	-		

#### **Data Source Information**

Soil Survey Area: McKinley County Area, New Mexico, McKinley County and

Parts of Cibola and San Juan Counties

Survey Area Data: Version 13, Sep 12, 2018

108° 2' 18" W

35° 29' 49" N

108° 2' 18" W

35° 28' 28" N

#### Soil Survey Area: McKinley County Area, New Mexico, McKinley This product is generated from the USDA-NRCS certified data as distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator Date(s) aerial images were photographed: Feb 19, 2016—Oct The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background projection, which preserves direction and shape but distorts Soil map units are labeled (as space allows) for map scales Source of Map: Natural Resources Conservation Service imagery displayed on these maps. As a result, some minor Albers equal-area conic projection, should be used if more The soil surveys that comprise your AOI were mapped at Please rely on the bar scale on each map sheet for map accurate calculations of distance or area are required. County and Parts of Cibola and San Juan Counties Coordinate System: Web Mercator (EPSG:3857) MAP INFORMATION Survey Area Data: Version 13, Sep 12, 2018 shifting of map unit boundaries may be evident. of the version date(s) listed below. Web Soil Survey URL: 1:50,000 or larger. measurements. Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background MAP LEGEND ŧ Not rated or not available Not rated or not available Area of Interest (AOI) > 1155 and <= 3415 > 1155 and <= 3415 > 700 and <= 1155 > 700 and <= 1155 > 338 and <= 540 > 540 and <= 700 > 540 and <= 700 > 338 and <= 540 > 540 and <= 700 > 338 and <= 540 Soil Rating Polygons Area of Interest (AOI) Soil Rating Points <= 338 Soil Rating Lines <= 338 <= 338

Not rated or not available

> 1155 and <= 3415

> 700 and <= 1155

Streams and Canals

Water Features

National Cooperative Soil Survey Web Soil Survey

USDA

#### Range Production (Favorable Year)

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI	
205	Penistaja-Tintero complex, 1 to 10 percent slopes	1155	248.8	19.6%	
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	3415	246.9	19.4%	
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	338	91.2	7.2%	
305	Celavar-Atarque complex, 1 to 8 percent slopes	683	195.7	15.4%	
338	Zyme-Lockerby association, 5 to 35 percent slopes	540	92.7	7.3%	
376	Todest fine sandy loam, 2 to 8 percent slopes	700	18.2	1.4%	
380	Berryhill-Casamero clays, 2 to 10 percent slopes	1140	378.4	29.8%	
Totals for Area of Inte	rest		1,271.8	100.0%	

#### **Description**

Total range production is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation. In a favorable year, the amount and distribution of precipitation and the temperatures make growing conditions substantially better than average. Yields are adjusted to a common percent of air-dry moisture content.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

#### **Rating Options**

Units of Measure: pounds per acre per year

Aggregation Method: Weighted Average
Component Percent Cutoff: None Specified

Tie-break Rule: Higher Interpret Nulls as Zero: Yes

108° 2' 18" W

35° 29' 49" N

USDA

108° 2' 18" W

35° 28' 28" N

## MAP LEGEND

#### Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background ŧ Not rated or not available Area of Interest (AOI) > 950 and <= 2090 > 225 and <= 425 > 425 and <= 810 > 810 and <= 950 Soil Rating Polygons Area of Interest (AOI)

# MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map measurements. Source of Map: Natural Resources Conservation Service Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required. This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 19, 2016—Oct

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Soil Rating Points

Not rated or not available

> 950 and <= 2090

> 225 and <= 425 > 425 and <= 810 > 810 and <= 950

Soil Rating Lines

<= 225

- > 425 and <= 810 > 225 and <= 425 <= 225
- > 950 and <= 2090 > 810 and <= 950
- Not rated or not available

### Water Features

Streams and Canals

USDA

#### **Range Production (Normal Year)**

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	810	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	2090	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	225	91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	425	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	360	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	400	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	950	378.4	29.8%
Totals for Area of Inte	rest		1,271.8	100.0%

#### **Description**

Total range production is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation. In a normal year, growing conditions are about average. Yields are adjusted to a common percent of air-dry moisture content.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

#### **Rating Options**

Units of Measure: pounds per acre per year Aggregation Method: Weighted Average Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Interpret Nulls as Zero: Yes

USDA

# MAP LEGEND

#### Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background ŧ Not rated or not available Area of Interest (AOI) > 760 and <= 1058 > 154 and <= 246 > 246 and <= 465 > 465 and <= 760 Soil Rating Polygons Area of Interest (AOI) <= 154

# MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map

measurements.
Source of Map: Natural Resources Conservation Service

Coordinate System: Web Mercator (EPSG:3857)

Web Soil Survey URL:

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 19, 2016—Oct

Not rated or not available

Soil Rating Points

<= 154

> 760 and <= 1058

> 465 and <= 760

> 246 and <= 465

> 154 and <= 246

Soil Rating Lines

<= 154

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Not rated or not available

> 760 and <= 1058

> 246 and <= 465 > 465 and <= 760

> 154 and <= 246

Streams and Canals

Water Features

#### Range Production (Unfavorable Year)

Map unit symbol	Map unit name	Rating (pounds per acre per year)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	465	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	1058	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	154	91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	246	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	135	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	240	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	760	378.4	29.8%
Totals for Area of Interest			1,271.8	100.0%

#### **Description**

Total range production is the amount of vegetation that can be expected to grow annually in a well managed area that is supporting the potential natural plant community. It includes all vegetation, whether or not it is palatable to grazing animals. It includes the current year's growth of leaves, twigs, and fruits of woody plants. It does not include the increase in stem diameter of trees and shrubs. It is expressed in pounds per acre of air-dry vegetation. In an unfavorable year, growing conditions are well below average, generally because of low available soil moisture. Yields are adjusted to a common percent of air-dry moisture content.

In areas that have similar climate and topography, differences in the kind and amount of vegetation produced on rangeland are closely related to the kind of soil. Effective management is based on the relationship between the soils and vegetation and water.

#### **Rating Options**

Units of Measure: pounds per acre per year

Aggregation Method: Weighted Average
Component Percent Cutoff: None Specified

Tie-break Rule: Higher Interpret Nulls as Zero: Yes

35° 29' 49" N

108° 2' 18" W

USDA

35° 28' 28" N

108° 2' 18" W

# MAP LEGEND

### Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background ŧ Not rated or not available Area of Interest (AOI) R035XG127NM R035XA128NM R036XB002NM R035XA119NM R035XA112NM Soil Rating Polygons Area of Interest (AOI)

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map

Source of Map: Natural Resources Conservation Service measurements.

Coordinate System: Web Mercator (EPSG:3857) Web Soil Survey URL:

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required. This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger. Date(s) aerial images were photographed: Feb 19, 2016—Oct

Not rated or not available

R035XG127NM

R036XB002NM

R035XA128NM

R035XA119NM

R035XA112NM

Soil Rating Lines

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Not rated or not available

R035XG127NM

R036XB002NM

R035XA128NM

R035XA119NM

R035XA112NM

Soil Rating Points

Streams and Canals

Water Features

USDA

### **Ecological Site ID: NRCS Rangeland Site**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	R035XA112NM	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	R035XA119NM	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes		91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes		195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	R036XB002NM	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	R035XG127NM	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	R035XA128NM	378.4	29.8%
Totals for Area of Inter	rest		1,271.8	100.0%

### **Description**

An "ecological site ID" is the symbol assigned to a particular ecological site. An "ecological site" is the product of all the environmental factors responsible for its development. It has characteristic soils that have developed over time; a characteristic hydrology, particularly infiltration and runoff, that has developed over time; and a characteristic plant community (kind and amount of vegetation). The vegetation, soils, and hydrology are all interrelated. Each is influenced by the others and influences the development of the others. For example, the hydrology of the site is influenced by development of the soil and plant community. The plant community on an ecological site is typified by an association of species that differs from that of other ecological sites in the kind and/or proportion of species or in total production. Descriptions of ecological sites are provided in the Field Office Technical Guide, which is available in local offices of the Natural Resources Conservation Service.

### **Rating Options**

Class: NRCS Rangeland Site

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

108° 2' 18" W

35° 29' 49" N

USDA

108° 2' 18" W

35° 28' 28" N

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USDA

### **Pond Reservoir Areas**

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero	Very limited	Penistaja (45%)	Seepage (1.00)	248.8	19.6%
	complex, 1 to 10 percent		Tintero (40%)	Seepage (1.00)		
	slopes			Slope (0.32)		
230	Sparank-San Mateo-Zia	Very limited	San Mateo (35%)	Seepage (1.00)	246.9	19.4%
	complex, 0 to 3 percent		Zia (20%)	Seepage (1.00)		
	slopes		Escawetter (1%)	Seepage (1.00)		
290	Rock outcrop- Westmion-	Not rated	Rock outcrop (45%)		91.2	7.2%
	Skyvillage complex, 30 to		Hospah (6%)			
	80 percent slopes		Vessilla (2%)			
	оюрео		Skyvillage (2%)			
305	Celavar-Atarque complex, 1 to	Somewhat limited	Celavar (50%)	Depth to bedrock (0.83)	195.7	15.4%
	8 percent slopes			Seepage (0.70)		
				Slope (0.08)		
338	Zyme-Lockerby	Very limited	Zyme (50%)	Slope (1.00)	92.7	7.3%
	association, 5 to 35 percent slopes			Depth to bedrock (0.66)		
			Lockerby (40%)	Slope (1.00)		
				Depth to bedrock (0.23)		
376	Todest fine sandy loam, 2	Somewhat limited	Todest (80%)	Depth to bedrock (0.98)	18.2	1.4%
	to 8 percent slopes			Seepage (0.72)		
				Slope (0.32)		
380	Berryhill-	Somewhat	Berryhill (50%)	Slope (0.32)	378.4	29.8%
	Casamero clays, 2 to 10	limited	Casamero (45%)	Slope (0.68)		
	percent slopes			Depth to bedrock (0.54)		
Totals for Area	of Interest				1,271.8	100.0%

	_	
Rating	Acres in AOI	Percent of AOI
Somewhat limited	592.3	46.6%
Very limited	588.3	46.3%
Null or Not Rated	91.2	7.2%

Rating	Acres in AOI	Percent of AOI
Totals for Area of Interest	1,271.8	100.0%

### **Description**

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the saturated hydraulic conductivity (Ksat) of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00).

The map unit components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as listed for the map unit. The percent composition of each component in a particular map unit is presented to help the user better understand the percentage of each map unit that has the rating presented.

Other components with different ratings may be present in each map unit. The ratings for all components, regardless of the map unit aggregated rating, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

### **Rating Options**

Aggregation Method: Dominant Condition
Component Percent Cutoff: None Specified

Tie-break Rule: Higher

USDA

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USDA

### MAP LEGEND

### Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background ŧ Not rated or not available Area of Interest (AOI) Hydric (66 to 99%) Hydric (33 to 65%) Hydric (1 to 32%) Not Hydric (0%) Hydric (100%) Soil Rating Polygons Area of Interest (AOI)

# MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map measurements. Source of Map: Natural Resources Conservation Service Web Soil Survey URL:

Coordinate System: Web Mercator (EPSG:3857)

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required. This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales

1:50,000 or larger.

Date(s) aerial images were photographed: Feb 19, 2016—Oct

Not rated or not available

Hydric (66 to 99%) Hydric (33 to 65%)

Hydric (100%)

Soil Rating Points

Hydric (1 to 32%)

Not Hydric (0%)

Hydric (66 to 99%) Hydric (33 to 65%)

Hydric (100%)

Soil Rating Lines

Hydric (1 to 32%)

Not Hydric (0%)

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Streams and Canals

Water Features

Not rated or not available

### **Hydric Rating by Map Unit**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	0	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	1	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	0	91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	0	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	0	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	0	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	0	378.4	29.8%
Totals for Area of Inter	rest		1,271.8	100.0%

### **Description**

This rating indicates the percentage of map units that meets the criteria for hydric soils. Map units are composed of one or more map unit components or soil types, each of which is rated as hydric soil or not hydric. Map units that are made up dominantly of hydric soils may have small areas of minor nonhydric components in the higher positions on the landform, and map units that are made up dominantly of nonhydric soils may have small areas of minor hydric components in the lower positions on the landform. Each map unit is rated based on its respective components and the percentage of each component within the map unit.

The thematic map is color coded based on the composition of hydric components. The five color classes are separated as 100 percent hydric components, 66 to 99 percent hydric components, 33 to 65 percent hydric components, 1 to 32 percent hydric components, and less than one percent hydric components.

In Web Soil Survey, the Summary by Map Unit table that is displayed below the map pane contains a column named 'Rating'. In this column the percentage of each map unit that is classified as hydric is displayed.

Hydric soils are defined by the National Technical Committee for Hydric Soils (NTCHS) as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, 1994). Under natural conditions, these soils are either saturated or inundated long enough during the growing season to support the growth and reproduction of hydrophytic vegetation.

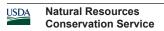
The NTCHS definition identifies general soil properties that are associated with wetness. In order to determine whether a specific soil is a hydric soil or nonhydric soil, however, more specific information, such as information about the depth and duration of the water table, is needed. Thus, criteria that identify those estimated soil properties unique to hydric soils have been established (Federal Register, 2002). These criteria are used to identify map unit components that normally are associated with wetlands. The criteria used are selected estimated soil properties that are described in "Soil Taxonomy" (Soil Survey Staff, 1999) and "Keys to Soil Taxonomy" (Soil Survey Staff, 2006) and in the "Soil Survey Manual" (Soil Survey Division Staff, 1993).

If soils are wet enough for a long enough period of time to be considered hydric, they should exhibit certain properties that can be easily observed in the field. These visible properties are indicators of hydric soils. The indicators used to make onsite determinations of hydric soils are specified in "Field Indicators of Hydric Soils in the United States" (Hurt and Vasilas, 2006).

### References:

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.



Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436.

Soil Survey Staff. 2006. Keys to soil taxonomy. 10th edition. U.S. Department of Agriculture, Natural Resources Conservation Service.

### **Rating Options**

Aggregation Method: Percent Present

Component Percent Cutoff: None Specified

Tie-break Rule: Lower

35° 29' 49" N

108° 2' 18" W

USDA



35° 28' 28" N

108° 2' 18" W

### MAP LEGEND

### Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Transportation Background ŧ Not rated or not available Area of Interest (AOI) > 0.12 and <= 0.13> 0.13 and <= 0.14> 0.17 and <= 0.20> 0.14 and <= 0.17Soil Rating Polygons Area of Interest (AOI) <= 0.12

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Source of Map: Natural Resources Conservation Service Please rely on the bar scale on each map sheet for map measurements.

Coordinate System: Web Mercator (EPSG:3857) Web Soil Survey URL:

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required. This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger. Date(s) aerial images were photographed: Feb 19, 2016—Oct

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

### > 0.13 and <= 0.14

> 0.12 and <= 0.13<= 0.12

Not rated or not available

Soil Rating Points

> 0.17 and <= 0.20

> 0.12 and <= 0.13

Soil Rating Lines <= 0.12 > 0.13 and <= 0.14> 0.14 and <= 0.17

- > 0.14 and <= 0.17
- > 0.17 and <= 0.20
- Not rated or not available

### Water Features

Streams and Canals

### **Soil Health - Available Water Capacity**

Map unit symbol	Map unit name	Rating (centimeters per centimeter)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	0.12	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	0.20	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes		91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	0.17	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	0.19	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	0.13	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	0.14	378.4	29.8%
Totals for Area of Inte	rest		1,271.8	100.0%

### **Description**

Available water capacity (AWC) refers to the quantity of water that the soil is capable of storing for use by plants. It is expressed in centimeters of water per centimeter of soil for each soil layer.

### Significance:

Available water capacity is an indicator of a soil's ability to retain water and make it sufficiently available for plant use. In areas where daily rainfall is insufficient to meet plant needs, the capacity of soil to store water is very important (USDA-NRCS, 2008). Water held in the soil is needed to sustain plants between rainfall or irrigation events and provide a buffer against periods of water deficit. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure, with corrections for salinity and rock fragments. Available water capacity determinations are used to develop water budgets, predict droughtiness, design and operate irrigation systems, design drainage systems, protect water resources, and predict yields (Lowery et al., 1996). They also are an important factor in the choice of plants or crops to be grown. The available water capacity can be increased by applying soil management that maximizes the soil's inherent capacity to store water. Improving soil structure and ameliorating compacted zones can improve both the storage capacity of the soil itself and increase the depth to which plant roots can penetrate.

### Factors Affecting Available Water Capacity:

Inherent factors.—Available water capacity is affected by soil texture, amount of rock fragments, and a soil's depth and layers. It is primarily controlled by soil texture and structure. Soils with higher silt contents generally have higher available water capacities, while sandy soils have the lowest available water capacities. Rock fragments reduce a soil's available water capacity proportionate to their volume, unless the rocks are porous. Soil depth and root-restricting layers affect the total available water capacity since they can limit the volume of soil available for root growth.

Dynamic factors.—Available water capacity is affected by soil organic matter, compaction, and salt concentrations. Organic matter can increase a soil's capacity to store water, on average, equivalent to its weight in available water (Libohova et al., 2018). Indirectly, organic matter improves soil structure and aggregate stability, resulting in increased pore size and volume. These soil improvements result in increased infiltration and movement of water through the soil. Greater amounts of water entering the soil can then be used by plant roots. Compaction reduces the available water capacity by reducing the total pore volume. Soils with high salt concentrations have a reduced available water capacity. Solutes in soil water attract water (osmotic potential), making it difficult for plant roots to extract or uptake the water.

### Measurement:

Available water capacity is determined in the lab by measuring the water content at field capacity (33 kPa) and wilting point (1500 kPa) and calculating the

difference (Soil Survey Staff, 2014). Pressure plates or membranes are used to bring the soil sample to a desired matric potential (33 kPa or 1500 kPa). When at equilibrium, the soil sample is removed and dried to determine its water content.

### References:

Libohova, Z., C. Seybold, D. Wysocki, S. Wills, P. Schoeneberger, C. Williams, D. Lindbo, D. Stott, and P.R. Owens. 2018. Reevaluating the effects of soil organic matter and other properties on available water-holding capacity using the National Cooperative Soil Survey Characterization Database. Journal of Soil and Water Conservation 73(4):411-421.

Lowery, B., M.A. Arshad, R. Lal, and W.J. Hickey. 1996. Soil water parameters and soil quality. In: J.W. Doran and A.J. Jones (eds.) Methods for assessing soil quality. Soil Science Society of America Special Publication 49:143-157.

Soil Survey Staff. 2014. Kellogg Soil Survey Laboratory methods manual. Soil Survey Investigations Report No. 42, Version 5.0. R. Burt and Soil Survey Staff (eds.). U.S. Department of Agriculture, Natural Resources Conservation Service.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2008. Soil quality indicators—Available water capacity.

### **Rating Options**

Units of Measure: centimeters per centimeter Aggregation Method: Dominant Component Component Percent Cutoff: None Specified

Tie-break Rule: Higher Interpret Nulls as Zero: No

Layer Options (Horizon Aggregation Method): Surface Layer (Not applicable)

USDA

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### MAP LEGEND

### Not rated or not available Streams and Canals Interstate Highways Aerial Photography Major Roads Local Roads US Routes Rails Water Features **Transportation** Background ŧ Not rated or not available Area of Interest (AOI) Soil Rating Polygons Area of Interest (AOI) 100 - 150150 - 200 50 - 100 25 - 50 > 200

### MAP INFORMATION

The soil surveys that comprise your AOI were mapped at

Please rely on the bar scale on each map sheet for map

Source of Map: Natural Resources Conservation Service Web Soil Survey URL: measurements.

Coordinate System: Web Mercator (EPSG:3857)

distance and area. A projection that preserves area, such as the Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required. This product is generated from the USDA-NRCS certified data as of the version date(s) listed below. Soil Survey Area: McKinley County Area, New Mexico, McKinley County and Parts of Cibola and San Juan Counties Survey Area Data: Version 13, Sep 12, 2018

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Feb 19, 2016—Oct

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Not rated or not available

> 200

Soil Rating Points

0 - 25

50 - 100

25 - 50

Soil Rating Lines

0 - 25

100 - 150

50 - 100

25 - 50

150 - 200

> 200

USDA

### **Depth to Water Table**

Map unit symbol	Map unit name	Rating (centimeters)	Acres in AOI	Percent of AOI
205	Penistaja-Tintero complex, 1 to 10 percent slopes	>200	248.8	19.6%
230	Sparank-San Mateo-Zia complex, 0 to 3 percent slopes	>200	246.9	19.4%
290	Rock outcrop- Westmion-Skyvillage complex, 30 to 80 percent slopes	>200	91.2	7.2%
305	Celavar-Atarque complex, 1 to 8 percent slopes	>200	195.7	15.4%
338	Zyme-Lockerby association, 5 to 35 percent slopes	>200	92.7	7.3%
376	Todest fine sandy loam, 2 to 8 percent slopes	>200	18.2	1.4%
380	Berryhill-Casamero clays, 2 to 10 percent slopes	>200	378.4	29.8%
Totals for Area of Inter	rest		1,271.8	100.0%

### **Description**

"Water table" refers to a saturated zone in the soil. It occurs during specified months. Estimates of the upper limit are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used.

### Rating Options

Units of Measure: centimeters

Aggregation Method: Dominant Component Component Percent Cutoff: None Specified

Tie-break Rule: Lower

Interpret Nulls as Zero: No Beginning Month: January Ending Month: December

# tronox naum 32 and 33



January 30, 2019

### Wetlands

Estuarine and Marine Deepwater

Estuarine and Marine Wetland

Freshwater Forested/Shrub Wetland Freshwater Pond

Lake

Freshwater Emergent Wetland

Other

Riverine

National Wetlands Inventory (NWI) This page was produced by the NWI mapper



### **IAS Laboratories**

2515 East University Drive Phoenix, Arizona 85034 (602) 273-7248 Fax (602) 275-3836

Date: December 13, 2018
Submitted by: Weston Solutions

Report To: David Bordelon

Report #: 6661724

Date Received: December 6, 2018

-X-

### **PLANT ANALYSIS**

Sender	Lab	Iron	Zinc	Copper	Manganese	Molybdenum	Uranium	Vanadium	Selenium
I.D.	No	mdd	ppm	ppm	mdd	mdd	ppm	mdd	ppm
32/33-P01-181127	180	1082.4	19.72	3.96	42.52	66'0	<0.10	09:0	0.14
32/33-P02-181127	181	2,287.5	33.81	5.71	48.36	8.60	2.27	06'9	0.74
32/33-P03-181127	182	260.4	21.88	4.01	55.18	0.91	10.73	1.55	0.82
32/33-P04-181127	183	2,471.3	27.56	5.92	109.4	1.17	7.58	06'9	<0.10
32/33-P05-181128	184	282.6	20.37	4.00	20.64	0.52	<0.10	1.55	0.75
32/33-P06-181128	185	253.4	23.60	6.12	39.74	0.52	<0.10	0.31	1.89
32/33-P07-181128	186	191.8	24.14	4.01	21.27	0.51	0.87	0.11	<0.10
32/33-P08-181128	187	602.9	20.73	4.03	29.08	0.51	<0.10	1.77	<0.10



2515 East University Drive Phoenix, Arizona 85034 (602) 273-7248

32 33 181127

Grower

Submitted By Weston Solutions Send To Weston Solutions

Report Number 6661724

**Date Received** 12/06/2018

Soil Analysis Report

VL = Very Low L = Low M = Medium H = High VH = Very High

Molybdenum	(Mo)	mdd	0	0.01	0	0.01	0	0.02
Free	Lime	Level	Med	Med	Low	Med	Med	Med
Boron	(B)	mdd	7 9E'0	0.34 L	7 EE'0	7 9E'0	7 EE'0	7 69 <sup>.</sup> 0
Sulfur	(SO4-S)	mdd	7.7 L	44.0 VH	5.3 VL	42.0 VH	8.0 L	13.0 M
Computed	%Sodium	(dsə)	9.0	8.0	0.4	1.9	9.0	1.8
Phosphate	(PO4-P)	mdd	7.6 L	12.0 M	7.9 L	9.3 L	7.7 L	9°3 L
Nitrate	(N-EON)	mdd	21.0 H	8.1 L	5.4 VL	14.0 M	7 6.8	12.0 M
Salinity	(EC x 2)	dS/m	8.0	1.2	9.0	1.4	8.0	1.0
Copper	(Cu)	mdd	0.50 M	0.72 M	0.43 M	0.96 M	0.59 M	0.92 M
Manganese	(Mn)	mdd	1.7 M	2.3 M	1.3 M	2.2 M	2.0 M	1.8 M
Zinc	(Zn)	mdd	0.40 L	0.32 L	0.21 L	0.31 L	0.25 L	0.14 VL
Iron	(Fe)	mdd	6.8 M	12.0 M	6.0 M	7.9 M	6.0 M	6.5 M
Potash	<u> </u>	mdd	HV 009	380 H	540 VH	470 H	500 VH	270 M
Sodium	(Na)	mdd	32 L	7 EE	14 VL	130 M	79 T	150 M
Calcium Magnesium Sodium	(Mg)	mdd	510 VH	Z10 M	230 H	350 H	280 H	HA 029
Calcium	(Ca)	mdd	4600 H	3100 M	2200 L	5100 H	3400 M	6100 VH
	Hd		8.20	8.14	8.15	8.15	8.32	8.26
	Lab		501	502	503	504	505	506
Sender	Sample	<u>p</u>	32/33-S03- 181127	32/33-S04- 181127	32/33-S05- 181127	32/33-S06- 181127	32/33-S07- 181127	32/33-S08- 181127

2515 East University Drive Phoenix, Arizona 85034 (602) 273-7248

Weston Solutions 32 33 181127 Submitted By

Grower

Weston Solutions Send To

6661724 Report Number

Date Received

12/06/2018

Soil Analysis Report

VL = Very Low L = Low M = Medium H = High VH = Very High

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	Texture			Loam	Sandy Clay Loam	Sandy Clay Loam	Clay Loam	Sandy Clay Loam	Clay
Soil  -	<u> </u>			_	Sandy	Sandy	Cla	Sandy	
Clay			%	26	24	20	36	24	54
Silt			%	30	18	16	30	24	22
Sand			%	44	58	64	34	52	24
Gypsum	Requirement		Tons/Acre						
Cation	Exchange	Capacity	MEQ/100G						
Organic	Matter		%						
Lab	#			501	502	503	504	202	909
Depth									
Sender	Sample	Number		32/33-S03-181127	32/33-S04-181127	32/33-S05-181127	32/33-S06-181127	32/33-S07-181127	32/33-S08-181127



### **AS Laboratories**

2515 East University Drive Phoenix, Arizona 85034 (602) 273-7248

Weston Solutions 32 33 181127 Submitted By Grower

Weston Solutions 6661724 Report Number Send To

12/06/2018 Date Received

Soil Analysis Report

Pounds/1000 Square Feet

L = Low M = Medium H = High VH = Very High

VL = Very Low

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Leachir	Excess						
Lime							
Gypsum				# 09			
Elemental	Sulfur	*	* 2		*	* 01	* 01
Boron	В	.02 h					
Copper	Cu						
Manganese	Mn						
Zinc	Zn	1 g	.1 g	.2 g	1 g	.1 g	.2 g
Iron	Fe						
Sulfur	Ø						
Magnesium	Mg						
Potash	K20						
Nitrogen Phosphate	P205	2 b	4 L	2 b	2 b	9 Z	2 b
Nitrogen	z	1 a	2 a	2 a	1 a	2 a	1 a
Crop		Landscape	Landscape	Landscape	Landscape	Landscape	Landscape
Sender	<u>p</u>	32/33-S03- 181127	32/33-S04- 181127	32/33-S05- 181127	32/33-S06- 181127	32/33-S07- 181127	32/33-S08- 181127

### Landscape

- a) Broadcast 1-2 lbs of nitrogen per 1000 sqft and water the nitrogen into the soil.
- b) Broadcast 1-2.5 lbs of phosphorus per 1000 sqft and till the phosphorus into the soil where possible. Phosphorus works best when it is closest to the roots. Phosphorus is required to make every cell in the plants (DNA formation) and is necessary for the plants energy cycle (ATP synthesis). When the plants cannot find phosphorus, the plants will focus all of its energy to grow roots and not leaves. If the plants cannot find enough phosphorus, they will run out of energy and stop producing foliage. If phosphorus deficiency is prolonged, the plants will begin to die.
- g) Apply 0.1 lbs of zinc sulfate per 1000 sqft to balance the micronutrients. There should be more zinc than copper available in the soil
- h) Apply boron by dissolving it in water and they spray it over the soil. If you cannot find a boron fertilizer you can use 20 mule team borax located in the laundry isle. If you use borax, mix 1 tbsp into 5 gallons of water. Then apply 2 gallons of solution per 1000 sqft
- dissolve readily and can be used if you can't till. This sulfur application will also increase the overall sulfur content in the soil, which is needed for enzyme formation in \*) Incorporate 5-10 lbs of elemental sulfur per 1000 sqft into the soil to reduce the soil pH. Disper/sul or SSP are sulfur products that should nitrogen utilization.
- #) Apply 50 lb of gypsum per 1000 sqft to balance the salts and increase the amount of oxygen in the soil to reduce seed and root rot. This sulfur application will also increase the overall sulfur content in the soil, which is needed for enzyme formation in nitrogen utilization.



### **IAS Laboratories**

2515 East University Drive Phoenix, Arizona 85034 (602) 273-7248 Fax (602) 275-3836 **Date**: December 13, 2018 **Submitted by**: Weston Solutions

Report To: David Bordelon

**Report #**: 6661724

Date Received: December 6, 2018

### **SOIL ANALYSIS**

\* \* \* \* \*

Sender	Lab	Total Carbon	Total Nitrogen	C:N	Water Holding Capacity - 0 Bar
I.D.	No	%	%		%
32/33-S03-181127	501	2.25	0.033	68:1	53.13
32/33-S04-181127	502	2.28	0.005	473:1	43.67
32/33-S05-181128	503	2.01	<0.001	3722:1	48.03
32/33-S06-181128	504	2.42	0.027	90:1	55.12
32/33-S07-181128	505	2.12	0.001	2385:1	45.34
32/33-S08-181128	506	2.16	0.001	1801:1	55.65

<sup>\*</sup>AOAC Official Method 993.13

<sup>\*\*</sup>ASTM D3152-72

Transect 1	From (cm)	To (cm)	Coverage (cm)	SP Code
	51	62	11	BOGR
	78	82	4	BOGR
	110	121	11	BOGR
	149	155	6	BOGR
	251	272	21	BOGR
	278	281	3	BOGR
	295	310	15	BOGR
	349	371	22	BOGR
	471	662	191	JUMO
	673	675	2	BOGR
	795	805	10	BOGR
	830	858	28	BOGR
	890	910	20	BOGR
	1250	1253	3	FEOC
	1255	1267	12	BOGR
	1281	1292	11	BOGR
	1301	1372	71	FEOC
	1380	1385	5	JUMO
	1390	1780	390	PIED
	1940	1950	10	ATCA
	2020	2067	47	JUMO
	2083	2181	98	PIED
	2240	2246	6	BOGR
	2302	2305	3	BOGR
	2311	2348	37	BOGR
	2490	2514	24	PLJA
	2531	2538		PLJA
	2570	2581	11	PLJA
	2602	2608	-	PLJA
	2701	2706	5	PLJA
	2735	2739	4	BOGR
	2802	2818	16	BOGR
	2845	2851	6	BOGR
TOTAL			1116	

Species	Cover	%Overall Cover	%Relative Cover
ATCA	10	0.33	0.90
BOGR	248	8.27	22.22
FEOC	74	2.47	6.63
JUMO	243	8.10	31.77
PIED	488	16.27	43.73
PLJA	53	1.77	4.75
TOTAL	1116	37.2	

Transect 2	From (cm)	To (cm)	Coverage (cm)	SP Code
	0	2	2	PLJA
	25	35	10	PLJA
	50	131	81	PLJA
	181	210		PLJA
	205	245	40	PLJA
	261	272		PLJA
	280	291		PLJA
	371	392		PLJA
	480	490		PLJA
	501	515		PLJA
	531	535		PLJA
	549	556		PLJA
	581	591		PLJA
	630	660		PLJA
	702	715		PLJA
	764	713		PLJA
	820	831		BOGR
	849	856		BOGR
	865	878		BOGR
	901	911		PLJA
	901	943		PLJA
	971	982		PLJA
	1020	1071		PLJA
	1115	1120		PLJA
	1113	1142		PLJA
	1153	1172		PLJA
	1175	1181		PLJA
	1201	1236		PLJA
	1249	1255		PLJA
	1289	1301		PLJA
	1340	1361		PLJA
	1440	1451		BOGR
	1481	1492		PLJA
	1505	1515		PLJA
	1530	1549		BOGR
	1570	1581		BOGR
	1610	1645		PLJA
	1651	1656		BOGR
	1670	1675		BOGR
	1678	1682		BOGR
	1710	1730		BOGR
	1733	1737		BOGR
	1752	1758		PLJA
	1785	1796		PLJA
	1841	1861		PLJA
	1882	1890		PLJA
	1890	1930		ATCA
	1949	2061		ATCA
	2135	2180	45	ATCA
	2201	2220	19	BOGR
	2232	2248	16	BOGR
	2239	2245	6	PLJA
	2262	2280	18	BOGR
	2289	2331	42	PLJA
	2351	2360	9	BOGR
	2380	2410	30	BOGR
	2451	2510	59	BOGR
	2490	2688	198	ATCA

Species	Cover	%Overall Cover	%Relative Cover
ATCA	395	13.17	26.96
BOGR	348	11.60	23.75
PLJA	722	24.07	49.28
TOTAL	1465	48.83	

	2701	2731	30	PLJA
	2731	2750	19	BOGR
	2765	2790	25	PLJA
	2820	2851	31	BOGR
	2910	2931	21	BOGR
	2961	2973	12	BOGR
	2991	2995	4	BOGR
Total			1465	

Transect 3	From (cm)	To (cm)	Coverage (cm)	SP Code
Transect 5	12	48		AGSM
				ATCA
	51	59		
	81	83		AGSM
	110	130		PLJA
	151	171		SATR
	174	191		PLJA
	220	235		SATR
	248	255		PLJA
	261	273		SATR
	321	410	89	ATCA
	411	430	19	PLJA
	430	450	20	ATCA
	451	499	48	PLJA
	500	545	45	ATCA
	555	560	5	PLJA
	570	588	18	ATCA
	630	665	35	PLJA
	670	750		PLJA
	760	799	39	PLJA
	800	885		ATCA
	940	960		ATCA
	1010	1058		PLJA
	1065	1070		BOGR
	1105	1120		PLJA
	1150	1178		BOGR
	1194	1202		PLJA
	1235	1255		PLJA
	1270	1285		BOGR
	1299	1395		PLJA
	1424	1445		PLJA
	1460	1470		PLJA
	1501	1512		PLJA
	1555	1572		PLJA
	1615	1640		PLJA
	1645	1650		PLJA
	1675	1691		PLJA
	1704	1761		PLJA
	1810	1828		PLJA
	1845	1870 1918		PLJA
	1908 1938			AGSM
	1	1958		AGSM
	1980	2011		ATCA
	2021	2058		PLJA
	2122	2151		PLJA
	2152	2164		ATCA
	2165	2171		AGSM
	2172	2205		PLJA
	2248	2265		AMSP
	2318	2337		AMSP
	2372	2390		PLJA
	2448	2460		ATCA
	2554	2765		PLJA
	2620	2631		BOGR
	2649	2688		PLJA
	2728	2740		PLJA
	2766	2780		AGSM
	2810	2840		AGSM
	2870	2875	5	AMSP
	2890	2900	10	AGSM

			_	
Species	Cover	%Overall Cover	%Relative Cover	
AGSM	128	4.27		7.36
AMSP	41	1.37		2.36
ATCA	422	14.07		24.28
BOGR	59	1.97		3.39
PLJA	1041	34.70		59.90
SATR	47	1.57		2.70
TOTAL	1738	57.93		

	2918	3000	82	ATCA
TOTAL			1738	

Transect 4	From (cm)	To (cm)	Coverage (cm)	SP Code
	58	72	14	VEGH
	72	191	119	ATCA
	275	284	9	RATA
	298	301	3	SATR
	332	348	16	ATCA
	571	581	10	RATA
	582	589	7	VEGH
	590	620	30	RATA
	621	740	119	ATCA
	774	781	7	VEGH
	789	821	32	ATCA
	985	988	3	VEGH
	990	1138	148	ATCA
	1170	1195	25	RATA
	1338	1345	7	RATA
	1346	1381	35	ATCA
	1405	1518	113	ATCA
	1551	1559	8	VEGH
	1748	1989	241	ATCA
	2088	2118	30	ATCA
	2220	2248	28	ATCA
	2278	2301	23	RATA
	2302	2350	48	ATCA
	2469	2492	23	VEGH
	2520	2538	18	RATA
	2701	2762	61	ATCA
	2804	2820	16	RATA
	2821	2941	120	ATCA
	2951	2955		AMSP
TOTAL			1317	

Species	Cover	%Overall Cover	%Relative Cover
AMSP	4	0.13	0.30
ATCA	1110	37.00	84.28
VEGH	62	2.07	4.71
RATA	138	4.60	10.48
SATR	3	0.10	0.23
TOTAL	1317	43.90	

Transect 4	From (cm)	To (cm)	Coverage (cm)	SP Code
	140	160	20	ATCA
	279	285	6	ATCA
	521	580	59	ATCA
	911	929	18	ATCA
	2031	2160	129	ATCA
	2195	2221	26	ATCA
	63	71	8	DYSP
	1825	1879	54	GRNU
	31	33	2	KOSC
	651	658	7	KOSC
	1190	1203	13	KOSC
	1640	1695	55	KOSC
	2281	2285	4	KOSC
	1760	1774	14	PLJA
	1961	1969	8	PLJA
	1989	2011	22	PLJA
	2549	2581	32	PLJA
	2689	2701	12	PLJA
	2829	2836	7	PLJA
	2883	2894	11	PLJA
TOTAL			507	

9	Species	Cover	%Overall Cover	%Relative Cover
1	ATCA	258	8.60	50.89
[	DYSP	8	0.27	1.58
(	GRNU	54	1.80	10.65
H	KOSC	81	2.70	15.98
F	PLJA	106	3.53	20.91
	TOTAL	507	16.90	

SP Code	KOSC	KOSC	KOSC	ATCA	KOSC	KOSC	KOSC	GRNU	KOSC	VEGH	ATCA	AMSP	GRNU	AMSP	ATCA	AMSP	KOSC	BOGR	KOSC	ATCA	KOSC	KOSC	SATR	
Coverage (cm)	8	14	22	115	40	14	29	236	25	18	100	31	30	37	136	21	37	111	54	129	26	11	10	1246
To (cm)	38	135	245	361	401	445	531	791	841	1279	1420	1572	1602	1667	1825	1846	1918	2081	2175	2320	2628	2982	3000	
From (cm)	30	121	223	246	361	431	205	255	816	1261	1320	1541	1572	1630	1689	1825	1881	1970	2121	2191	7097	2971	2990	
Transect 6																								total

Species	Cover	%Overall Cover	%Relative Cover
AMSP	89	2.97	7.10
ATCA	480	16.00	38.28
VEGH	18	0.60	1.44
BOGR	111	3.70	8.85
GRNU	266	8.87	7 21.21
KOSC	280	9.33	22.33
SATR	10	0.33	0.80
TOTAL	1254	41.8	

Transect 7	From (cm)	To (cm)	Coverage (cm)	SP Code
	108	111	3	DYSp
	361	380	19	ATCA
	605	625	20	ATCA
	651	711	60	GRNU
	770	802	32	ATCA
	920	950	30	GRNU
	980	1006	26	ATCA
	1230	1270	40	ATCA
	1330	1340	10	KOSC
	1390	1405	15	KOSC
	1486	1491	5	KOSC
	1551	1553	2	AGSM
	1562	1576	14	AGSM
	1940	1983	43	BOGR
	2207	2209	2	AGSM
	2762	2791	29	GRNU
	2971	2975	4	KOSC
total			354	

ecies Cover %Overall Cover
SM 18 0.
CA 137 4.5
OGR 43 1.4
SP 3 0.:
RNU 119 3.9
OSC 34 1.:
TAL 354 11.

Transect 8	From (cm)	To (cm)	Coverage (cm)	SP Code
	0	10	10	KOSC
	11	19	8	KOSC
	78	89	11	KOSC
	101	117	16	KOSC
	137	141	4	KOSC
	171	202	31	G1
	241	248	7	G1
	296	304	8	KOSC
	340	351	11	KOSC
	438	479		KOSC
	530	551		KOSC
	750	761		G1
	878	891	13	AMSP
	949	972		G1
	995	1021		G1
	1062	1068	6	G1
	1120	1141		AMSP
	1151	1165	14	G1
	1181	1196		G1
	1228	1304		G1
	1490	1511		G1
	1548	1560		G1
	1570	1581		G1
	1589	1602		G1
	1630	1661	31	G1
	1670	1681	11	G1
	1741	1742		RUOC
	1751	1762		G1
	2140	2162	22	G1
	2171	2180	9	G1
	2208	2223	15	G1
	2230	2251	21	G1
	2270	2291	21	G1
	2305	2315	10	RUOC
	2330	2340		KOSC
	2351	2360	9	RUOC
	2420	2441	21	RUOC
	2518	2541	23	G1
	2690	2741	51	ATCA
	2768	2783	15	RUOC
	2940	2991	51	ATCA
TOTAL			762	

Species	Cover	%Overall Cover	%Relative Cover
AMSP	34	1.13	4.46
ATCA	102	3.40	13.39
G1	430	14.33	56.43
KOSC	140	4.67	18.37
RUOC	56	1.87	7.35
TOTAL	762	25.40	

# **APPENDIX C**

Vascular Plants Found in the Study Area

Vertebrate Species Found in the Study Area

#### **VASCULAR PLANTS**

# AGAVACEAE (Agave Family)

Yucca angustissima Engelm. Ex. Trel. (Narrowleaf yucca) Yucca glauca Nutt. (Great Plains yucca)

### **AMARANTHACEAE (Amaranth Family)**

Amaranthus retroflexus .Pigweed)
Amaranthus sp. L. (Amaranth)

# ANACARIDACEAE (Skunkbush family)

Rhus trilobata Nutt. (Skunkbush sumac)

# **APIACEAE (Carrot Family)**

Cymopterus bulbosus A. Nels. (Spring parsely)

#### ASCLEPIADACEAE (Milkweed Family)

Asclepias subverticillata (Gray) Vail (Whorled milkweed)

# **ASTERACEAE (Sunflower Family)**

Ambrosia acanthicarpa Hook (Flatspine bur ragweed)

Artemisia biqelovii Gray (Bigelow's sage)

Artemisia frigida Willd. (Fringed sage)

Artemisia ludoviciana Nutt. (White sagebrush)

Artemisia tridentata Nutt. (Big sagebrush)

Chrysothamnus greenei (A. Gray) Greene (Greene's rabbitbrush)

Conyza canadensis (L.) Cronq. (Canadian horseweed)

Dyssodia papposa Hitch. (Dogweed)

Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird (Rubber rabbitbrush)

Erigeron divergens Torr. & A. Gray (Spreading fleabane)

Grindelia nuda Wood var. aphanactis (Rydb.) Nesom (Gumweed)

Gutierrezia sarothrae (Pursh) Britt. & Rusby (Broom snakeweed)

Helianthus annuus L. (Common sunflower)

Heterotheca canescens (DC.) Shinners (Hoary false golden aster)

Machaeranthera sp. (Golden aster)

Machaeranthera canescens (Pursh) Gray (Hoary aster)

Machaeranthera pinnatifida (Hook.) Shinners (Lace tansy aster)

Ratibita tagetes (James) Barnhart (Green prairie coneflower)

Senecio flaccidus Less. (Threadleaf groundsel)

Tetradymia canescens D.C. (Spineless horsebush)

Townsendia annua Beaman (Townsend's daisy)

Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray golden crownbeard

Xanthium strumarium L. (Cocklebur)

Zinnia grandiflora Nutt. (Rocky Mt. Zinnia)

#### **BORAGINACEAE** (Borage Family)

Cryptantha crassisepala (Torr. & A. Gray) Greene (Thicksepal cryptantha)
Cryptantha fendleri (A. Gray) Greene (Fendler cryptantha)
Cryptantha sp. Lehm. ex G. Don (Hidden flower)
Lappula occidentalis (S. Watson) Greene var. cupulata (A. Gray) Higgins flatspine stickseed

# **BRASSICACEAE** (Mustard Family)

Descurainia obtusa (Greene) O.E. Schulz (Blunt tansy mustard)
Descurainia sophia (L.) Webb ex Prantl (Tansy mustard)
Lepidum sp. (Pepperweed)
Sisymbrium altissimum L. (Tall tumblemustard)
Streptanthella longirostris (S. Watson) Rydb. (Long-beaked streptanthella)

# **CACTACEAE** (Cactus Family)

Echinocereus triglochidatus Engelm. var. gonacanthus (Kingcup cactus) Escobaria vivipara (Nutt.) Buxbaum (Pincushion cactus) Opuntia phaeacantha Engelmann (NM prickly pear) Opuntia polyacantha Haw. (Plains prickly pear)

# **CAPPARIDACEAE** (Caper Family)

Cleome serrulate (Rocky Mt. Bee Plant)

#### **CHENOPODIACEAE** (Goosefoot Family)

Atriplex canescens (Pursh) Nutt. (Four-wing saltbush)
Chenopodium leptophyllym (Moquin) S. Watson
Chenopodium L. sp. (Goosefoot)
Kochia scoparia (L.) Schrad. (Summer cypress)
Krascheninnikovia lanata (Pursh) A.D.J. Meeuse & Smit (Winterfat)
Salsola tragus L. (Russian thistle)

#### CUPRESSACEAE (Cypress Family)

Juniperus monosperma (Engelm.) Sarg (One-seed juniper)

# **EPHEDRACEAE** (Jointfir Family)

Ephedra torreyana S. Watson (Mormon tea)

# **EUPHORBIACEAE** (Spurge Family)

Chamaesyce fendleri (Torr. & Gray) Small (Fendler's sandmat) Chamaesyce serpyllifolia (Pers.) Small (Spurge)

# **FABACEAE** (Bean Family)

Medicago sativa L. (Alfalfa)
Melilotus officinalis (L.) Lam. (Yellow sweetclover)

# **GERANIACEAE** (Geranium Family)

Erodium cicutarium (L.) L'HÈr. ex Ait. (Crane's bill)

# LAMIACEAE (Mint Family)

Marrubium vulgare L. (Horehound)

# LILIACEAE (Lily Family)

Allium sp. (Onion)

# LOASACEAE (Loasa Family)

Mentzelia sp. (Blazing star)

#### MALVACEAE (Mallow Family)

Sphaeralcea coccinea (Nutt.) Rydb. (Scarlet globemallow)

# NYCTAGINACEAE (Four-o'clock Family)

Mirabilis multiflora (Torr.) Gray (Four-o'clock)

# PINACEAE (Pine Family)

Pinus edulis Engelm. (Pinyon pine) N

#### PLANTAGINACEAE (Plantain Family)

Plantago patagonica Jacq. (Wooly plaintain)

# **POACEAE** (Grass Family)

Achnatherum hymenoides (Roemer & J.A. Schultes) Barkworth (Indian ricegrass)

Agropyron sp. (Wheatgrass)

Aristida sp. (Threeawn)

Aristida adscensionis L. (Sixweeks threeawn)

Aristida purpurea Nutt. (Purple threeawn)

Aristida purpurea Nutt. var. longiseta (Steud.) Vasey (Red threeawn)

Bouteloua curtipendula (Michx.) Torr. (Sideoats grama)

Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths (Blue grama)

Bouteloua simplex Lagasca (Mat grama)

Elymus elymoides (Raf.) Swezey (Squirreltail)

Festuca octoflora Walter (Sixweeks fescue)

Muhlenbergia torreyi (Kunth) Hitch (Ring muhly)

Pascopyrum smithii (Rydb.) A. L^ve (Western wheatgrass)

Pleuraphis jamesii Torr. (Galleta)

Sporobolus airoides (Torr.) Torr. (Alkali sacaton)

Sporobolus cryptandrus (Torr.) Gray (Sand dropseed)

Sporobolus contractus Hitch (Spike dropseed)

# **POLYGONACEAE** (Buckwheat Family)

Eriogonum microthecum Nutt. (slender buckwheat)
Eriogonum jamesii Benth. (James buckwheat)
Eriogonum sp. Michx. (Buckwheat)
Rumex hymenosepalus Torr. (canaigre dock)
Rumex sp. (Dock)

# **PORTULACEAE** (Purselane Family)

Portulaca oleraceae L. (Purselane)

# **SOLANACEAE** (Nightshade Family)

Lycium pallidum Miers (Wolfberry)

**VERBENACEAE** (Vervain Family)

Verbena bracteata Lag. & Rodr. (Big-bract vervain)

# **VERTEBRATE ANIMALS**

	Scientific	Common
Birds		
	Buteo jamaicensis	Red-tailed hawk
	Corvus brachyrhynchos	American crow
	Corvus corax	Common raven
	Haemorphus mexicanus	House finch
	Junco hyemalis	Dark-eyed junco
	Geococcyx californianus	Greater roadrunner
	Eremophila alpestris	Horned lark
	Haemorhous mexicanus	House finch
	Zonotrichia leucophyrs	White-crowned sparrow
Mammals		
	Ammospermophilus sp.	Ground squirrel
	Geomyidae bottae	Botta Pocket gopher
	Canis latrans	Coyote
	Cynomys gunnisoni	Gunnison's prairie dog
	Dipodomys spectabilis	Banner-tailed kagaroo rat
	Dipodomys ordii	Ord's kangaroo rat
	Neotoma mexicana	Wood rat
	Odocoileus hemionus	Mule deer
	Sylvilagus audubonii	Desert cottontail
	Urocyon cinereoargenteus	Gray fox

# **APPENDIX D**

**USFWS County List** 

Navajo Heritage Data Request

**NMDGF** County List

New Mexico Forestry State Endangered Plants List

NM Rare Plant Technical Committee List

New Mexico Heritage S1 Species

New Mexico Noxious Weed List



# United States Department of the Interior

# FISH AND WILDLIFE SERVICE

New Mexico Ecological Services Field Office 2105 Osuna Road Ne Albuquerque, NM 87113-1001 Phone: (505) 346-2525 Fax: (505) 346-2542

http://www.fws.gov/southwest/es/NewMexico/ http://www.fws.gov/southwest/es/ES Lists Main2.html



In Reply Refer To: November 19, 2018

Consultation Code: 02ENNM00-2019-SLI-0219

Event Code: 02ENNM00-2019-E-00456

Project Name: Tronox 144000A

Subject: List of threatened and endangered species that may occur in your proposed project

location, and/or may be affected by your proposed project

# To Whom It May Concern:

Thank you for your recent request for information on federally listed species and important wildlife habitats that may occur in your project area. The U.S. Fish and Wildlife Service (Service) has responsibility for certain species of New Mexico wildlife under the Endangered Species Act (ESA) of 1973 as amended (16 USC 1531 et seq.), the Migratory Bird Treaty Act (MBTA) as amended (16 USC 701-715), and the Bald and Golden Eagle Protection Act (BGEPA) as amended (16 USC 668-668c). We are providing the following guidance to assist you in determining which federally imperiled species may or may not occur within your project area and to recommend some conservation measures that can be included in your project design.

# FEDERALLY-LISTED SPECIES AND DESIGNATED CRITICAL HABITAT

Attached is a list of endangered, threatened, and proposed species that may occur in your project area. Your project area may not necessarily include all or any of these species. Under the ESA, it is the responsibility of the Federal action agency or its designated representative to determine if a proposed action "may affect" endangered, threatened, or proposed species, or designated critical habitat, and if so, to consult with the Service further. Similarly, it is the responsibility of the Federal action agency or project proponent, not the Service, to make "no effect" determinations. If you determine that your proposed action will have "no effect" on threatened or endangered species or their respective critical habitat, you do not need to seek concurrence with the Service. Nevertheless, it is a violation of Federal law to harm or harass any federally-listed threatened or endangered fish or wildlife species without the appropriate permit.

If you determine that your proposed action may affect federally-listed species, consultation with the Service will be necessary. Through the consultation process, we will analyze information contained in a biological assessment that you provide. If your proposed action is associated with Federal funding or permitting, consultation will occur with the Federal agency under section 7(a) (2) of the ESA. Otherwise, an incidental take permit pursuant to section 10(a)(1)(B) of the ESA (also known as a habitat conservation plan) is necessary to harm or harass federally listed threatened or endangered fish or wildlife species. In either case, there is no mechanism for authorizing incidental take "after-the-fact." For more information regarding formal consultation and HCPs, please see the Service's Consultation Handbook and Habitat Conservation Plans at www.fws.gov/endangered/esa-library/index.html#consultations.

The scope of federally listed species compliance not only includes direct effects, but also any interrelated or interdependent project activities (e.g., equipment staging areas, offsite borrow material areas, or utility relocations) and any indirect or cumulative effects that may occur in the action area. The action area includes all areas to be affected, not merely the immediate area involved in the action. Large projects may have effects outside the immediate area to species not listed here that should be addressed. If your action area has suitable habitat for any of the attached species, we recommend that species-specific surveys be conducted during the flowering season for plants and at the appropriate time for wildlife to evaluate any possible project-related impacts.

# **Candidate Species and Other Sensitive Species**

A list of candidate and other sensitive species in your area is also attached. Candidate species and other sensitive species are species that have no legal protection under the ESA, although we recommend that candidate and other sensitive species be included in your surveys and considered for planning purposes. The Service monitors the status of these species. If significant declines occur, these species could potentially be listed. Therefore, actions that may contribute to their decline should be avoided.

Lists of sensitive species including State-listed endangered and threatened species are compiled by New Mexico state agencies. These lists, along with species information, can be found at the following websites:

Biota Information System of New Mexico (BISON-M): www.bison-m.org

New Mexico State Forestry. The New Mexico Endangered Plant Program: www.emnrd.state.nm.us/SFD/ForestMgt/Endangered.html

New Mexico Rare Plant Technical Council, New Mexico Rare Plants: nmrareplants.unm.edu

Natural Heritage New Mexico, online species database: nhnm.unm.edu

#### WETLANDS AND FLOODPLAINS

Under Executive Orders 11988 and 11990, Federal agencies are required to minimize the destruction, loss, or degradation of wetlands and floodplains, and preserve and enhance their natural and beneficial values. These habitats should be conserved through avoidance, or mitigated to ensure that there would be no net loss of wetlands function and value.

We encourage you to use the National Wetland Inventory (NWI) maps in conjunction with ground-truthing to identify wetlands occurring in your project area. The Service's NWI program website, www.fws.gov/wetlands/Data/Mapper.html integrates digital map data with other resource information. We also recommend you contact the U.S. Army Corps of Engineers for permitting requirements under section 404 of the Clean Water Act if your proposed action could impact floodplains or wetlands.

# **MIGRATORY BIRDS**

The MBTA prohibits the taking of migratory birds, nests, and eggs, except as permitted by the Service's Migratory Bird Office. To minimize the likelihood of adverse impacts to migratory birds, we recommend construction activities occur outside the general bird nesting season from March through August, or that areas proposed for construction during the nesting season be surveyed, and when occupied, avoided until the young have fledged.

We recommend review of Birds of Conservation Concern at website www.fws.gov/migratorybirds/CurrentBirdIssues/Management/BCC.html to fully evaluate the effects to the birds at your site. This list identifies birds that are potentially threatened by disturbance and construction.

#### BALD AND GOLDEN EAGLES

The bald eagle (*Haliaeetus leucocephalus*) was delisted under the ESA on August 9, 2007. Both the bald eagle and golden eagle (*Aquila chrysaetos*) are still protected under the MBTA and BGEPA. The BGEPA affords both eagles protection in addition to that provided by the MBTA, in particular, by making it unlawful to "disturb" eagles. Under the BGEPA, the Service may issue limited permits to incidentally "take" eagles (e.g., injury, interfering with normal breeding, feeding, or sheltering behavior nest abandonment). For information on bald and golden eagle management guidelines, we recommend you review information provided at www.fws.gov/midwest/eagle/guidelines/bgepa.html.

On our web site www.fws.gov/southwest/es/NewMexico/SBC\_intro.cfm, we have included conservation measures that can minimize impacts to federally listed and other sensitive species. These include measures for communication towers, power line safety for raptors, road and highway improvements, spring developments and livestock watering facilities, wastewater facilities, and trenching operations.

We also suggest you contact the New Mexico Department of Game and Fish, and the New Mexico Energy, Minerals, and Natural Resources Department, Forestry Division for information regarding State fish, wildlife, and plants.

Thank you for your concern for endangered and threatened species and New Mexico's wildlife habitats. We appreciate your efforts to identify and avoid impacts to listed and sensitive species in your project area. For further consultation on your proposed activity, please call 505-346-2525 or email nmesfo@fws.gov and reference your Service Consultation Tracking Number.

# Attachment(s):

- Official Species List
- Migratory Birds

# Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

New Mexico Ecological Services Field Office 2105 Osuna Road Ne Albuquerque, NM 87113-1001 (505) 346-2525

# **Project Summary**

Consultation Code: 02ENNM00-2019-SLI-0219

Event Code: 02ENNM00-2019-E-00456

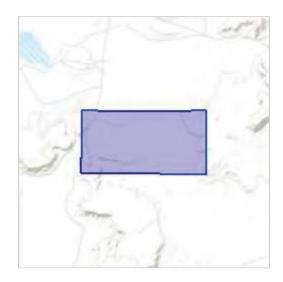
Project Name: Tronox 144000A

Project Type: VEGETATION MANAGEMENT

Project Description: Reveg

# Project Location:

Approximate location of the project can be viewed in Google Maps: <a href="https://www.google.com/maps/place/35.48592216940607N108.01715230496893W">https://www.google.com/maps/place/35.48592216940607N108.01715230496893W</a>



Counties: McKinley, NM

**STATUS** 

Endangered

# **Endangered Species Act Species**

Zuni Bluehead Sucker Catostomus discobolus yarrowi

Species profile: https://ecos.fws.gov/ecp/species/3536

There is **final** critical habitat for this species. Your location is outside the critical habitat.

There is a total of 5 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries<sup>1</sup>, as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

1. <u>NOAA Fisheries</u>, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

# **Birds**

NAME

NAME	STATUS
Mexican Spotted Owl <i>Strix occidentalis lucida</i> There is <b>final</b> critical habitat for this species. Your location is outside the critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/8196">https://ecos.fws.gov/ecp/species/8196</a>	Threatened
Southwestern Willow Flycatcher <i>Empidonax traillii extimus</i> There is <b>final</b> critical habitat for this species. Your location is outside the critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/6749">https://ecos.fws.gov/ecp/species/6749</a>	Endangered
Yellow-billed Cuckoo <i>Coccyzus americanus</i> Population: Western U.S. DPS There is <b>proposed</b> critical habitat for this species. Your location is outside the critical habitat. Species profile: <a href="https://ecos.fws.gov/ecp/species/3911">https://ecos.fws.gov/ecp/species/3911</a>	Threatened
Fishes	

# Flowering Plants

NAME

Zuni Fleabane Erigeron rhizomatus

Threatened

No critical habitat has been designated for this species. Species profile: <a href="https://ecos.fws.gov/ecp/species/5700">https://ecos.fws.gov/ecp/species/5700</a>

# Critical habitats

THERE ARE NO CRITICAL HABITATS WITHIN YOUR PROJECT AREA UNDER THIS OFFICE'S JURISDICTION.

# Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act<sup>1</sup> and the Bald and Golden Eagle Protection Act<sup>2</sup>.

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described <u>below</u>.

- 1. The Migratory Birds Treaty Act of 1918.
- 2. The Bald and Golden Eagle Protection Act of 1940.
- 3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

THERE ARE NO FWS MIGRATORY BIRDS OF CONCERN WITHIN THE VICINITY OF YOUR PROJECT AREA.

# Migratory Birds FAQ

# Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

# What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS <u>Birds of Conservation Concern</u> (<u>BCC</u>) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the <u>Avian Knowledge Network (AKN)</u>. The AKN data is based on a growing collection of <u>survey</u>, <u>banding</u>, <u>and citizen science datasets</u> and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (<u>Eagle Act</u> requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the E-bird Explore Data Tool.

# What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the <u>Avian Knowledge Network (AKN)</u>. This data is derived from a growing collection of <u>survey</u>, <u>banding</u>, <u>and citizen science datasets</u>.

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

# How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

# What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

- 1. "BCC Rangewide" birds are <u>Birds of Conservation Concern</u> (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
- 2. "BCC BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
- 3. "Non-BCC Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the <u>Eagle Act</u> requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

# Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the <a href="Northeast Ocean Data Portal">Northeast Ocean Data Portal</a>. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the <a href="NOAA NCCOS Integrative Statistical Modeling">NOAA NCCOS Integrative Statistical Modeling</a> and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic <a href="Outer Continental Shelf">Outer Continental Shelf</a> project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the <u>Diving Bird Study</u> and the <u>nanotag studies</u> or contact <u>Caleb Spiegel</u> or <u>Pam Loring</u>.

# What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to <u>obtain a permit</u> to avoid violating the Eagle Act should such impacts occur.

# Proper Interpretation and Use of Your Migratory Bird Report

The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.



PO BOX 1480 Window Rock, AZ 86515 P 928.871.6472 F 928.871.7603

www.nndfw.org

18m&a105

06-November-2018

C.J. Vialpando - Project Manager Marron and Associates 7511 Fourth Street NW Albuquerque, NM 87107

# **SUBJECT: Study Area for Proposed Uranium Mine Cleanup**

C.J. Vialpando,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

- 1. **Known Species** a list of all species within relative proximity to the project
- 2. Potential Species a list of potential species based on project proximity to respective suitable habitat
- 3. **Quadrangles** an exhaustive list of quads containing the project
- 4. **Project Summary** a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
- 5. Conditional Criteria Notes additional details concerning various species, habitat, etc.
- 6. **Personnel Contacts** a list of employee contacts
- 7. **Resources** identifies sources for further information

Known Species lists "species of concern" known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no "species of concern" within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (www.nndfw.org/nnhp/sp\_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of

these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

**1. Known Species** (NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)

#### **Species**

None

# 2. Potential Species

#### **Species**

AQCH = Aquila chrysaetos / Golden Eagle NESL G3

ATCU = Athene cunicularia / Burrowing Owl NESL G4

CHMO = Charadrius montanus / Mountain Plover NESL G4

ERAC = Erigeron acomanus / Acoma Fleabane NESL G3

ERSI = Erigeron sivinskii / Sivinski's Fleabane NESL G4

FAPE = Falco peregrinus / Peregrine Falcon NESL G4

LENA = Lesquerella navajoensis / Navajo Bladderpod NESL G3

# 3. Quadrangles (7.5 Minute)

#### Quadrangles

Goat Mountain (35107-D8) / NM Thoreau NE (35108-D1) / NM

**4. Project Summary** (EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	RCP
Study Area	None	None	Goat Mountain (35107-D8) / NM	None	AQCH, ATCU, FAPE	Area 3
Study Area	None	None	Thoreau NE (35108-D1) / NM	None	AQCH, ATCU, CHMO, ERAC, ERSI, FAPE, LENA	Area 3

**5. Conditional Criteria Notes** (Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)

**A. Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.

The following is a brief summary of six (6) wildlife areas:

- 1. Highly Sensitive Area recommended no development with few exceptions.
- 2. Moderately Sensitive Area moderate restrictions on development to avoid sensitive species/habitats.
- 3. Less Sensitive Area fewest restrictions on development.
- 4. Community Development Area areas in and around towns with few or no restrictions on development.
- 5. **Biological Preserve** no development unless compatible with the purpose of this area.
- 6. Recreation Area no development unless compatible with the purpose of this area.

None - outside the boundaries of the Navajo Nation

This is not intended to be a full description of the RCP please refer to the our website for additional information at <a href="https://www.nndfw.org/clup.htm">www.nndfw.org/clup.htm</a>.

**B. Raptors** – If raptors are known to occur within 1 mile of project location: Contact the NNHP zoologist at 871-7070 regarding your evaluation of potential impacts and mitigation.

Golden and Bald Eagles- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at <a href="https://www.nndfw.org/nnhp/docs">www.nndfw.org/nnhp/docs</a> reps/gben.pdf.

<u>Ferruginous Hawks</u> – Refer to *Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection* (<u>www.nndfw.org/nnhp/docs\_reps.htm</u>) for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.

<u>Mexican Spotted Owl</u> - Please refer to the *Navajo Nation Mexican Spotted Owl Management Plan* (<u>www.nndfw.org/nnhp/docs\_reps.htm</u>) for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

- **C. Surveys** Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts <a href="www.nndfw.org/nnhp/sp\_account.htm">www.nndfw.org/nnhp/sp\_account.htm</a>. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-6450 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW the NNHP Zoologist for animals, and the NNHP Botanist for plants. Questions regarding biological evaluation should be directed to Jeff Cole at 871-6450.
- **D. Oil/Gas Lease Sales** Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.
- **E. Power line Projects** These projects need to ensure that they do not violate the regulations set forth in the *Navajo Nation Raptor Electrocution Prevention Regulations* found at <a href="https://www.nndfw.org/nnhp/docs">www.nndfw.org/nnhp/docs</a> reps/repr.pdf.

- **F. Guy Wires** Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.
- **G. San Juan River** On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.
- **H. Little Colorado River** On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

- I. Wetlands In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency's Water Quality Program.
- **J. Life Length of Data Request** The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.
- K. Ground Water Pumping Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

# 6. Personnel Contacts

Wildlife Manager (Vacant) 928.871.7062

Zoologist (Acting Manager)
Chad Smith
928.871.7070
csmith@nndfw.org

Botanist
Nora Talkington
ntalkington@nndfw.org

Biological Reviewer Pamela Kyselka 928.871.7065 pkyselka@nndfw.org

GIS Supervisor Dexter D Prall 928.645.2898 prall@nndfw.org

Wildlife Tech
Sonja Detsoi
928.871.6472
sdetsoi@nndfw.org

# 7. Resources

Navajo Endangered Species List: www.nndfw.org/nnhp/endangered.htm

Species Accounts:

www.nndfw.org/nnhp/sp account.htm

Biological Investigation Permit Application www.nndfw.org/nnhp/study\_permit.htm

Navajo Nation Sensitive Species List www.nndfw.org/nnhp/trackinglist.htm

Various Species Management and/or Document and Reports

www.nndfw.org/nnhp/docs reps.htm

Consultant List www.nndfw.org/bi consult list 2014.pdf

Dexter D Prall, GIS Supervisor - Natural Heritage Program Navajo Nation Department of Fish and Wildlife



PO Box 1480 Window Rock, AZ 86515 P 928.871.6472 F 928.871.7603 http://nnhp.nndfw.org

# Invoice for 18m&a105

11/6/2018

Please make payable to NAVAJO NATION

# **Project Measurements**

Total Number of Quads: 2

Number of Additional Quads: 0

Cost (\$75 plus \$5 each additional Quad): \$75.00

(Please cut along the dashed line and return with payment)

Navajo Natural Heritage Program PO Box 1480 Window Rock, AZ 86515

11/6/2018

Payment for Data Response 18m&a105

\$75.00

**PLEASE PAY THIS AMOUNT** 

Please make payable to NAVAJO NATION

Or, if you would like to pay with a credit card, fill out and return the Credit Card Authorization Form with the invoice stub.







# Department of Fish and Wildlife Credit Card Authorization Form

Sign and complete this form to authorize the Navajo Nation Department of Fish and Wildlife to make a one-time charge to your credit card listed below.

By signing this form, you give us permission to charge your account for the amount indicated on or after the indicated date. This is permission for a single transaction only, and does not provide authorization for any additional, unrelated debits or credits to your account.

# Please complete the information below:

[ [Full Name]	authorize	the De	partment of	f Fish a	nd Wildlife	to charge my credit car
account indicated belo		75.00 mount)	on or afte	er1	1/6/2018 (Date)	This payment is for
	Н	Data Request Report - (Description of goods/s				35-
Billing Address					Pho	one #
City, State, Zip Code _	77			-	Em	ail
Account Type	√isa	Mas	stercard		AMEX	Discover
Cardholder Name						
Account #						
Expiration Date		_		CVV2		
Signature					Date	

I authorize the above named business to charge the credit card indicated in this authorization form according to the terms outlined above. This payment authorization is for the goods/services described above, for the amount indicated above only, and is valid for one time use only. I certify that I am an authorized user of this credit card and that I will not dispute the payment with my credit card company; so long as the transaction corresponds to the terms indicated on this form.





# Federal or State Threatened/Endangered Species McKinley

Taxonomic Group	# Species	Taxonomic Group	# Species
Fish	1	Mammals	1
Birds	9		

**TOTAL SPECIES: 11** 

Common Name	Scientific Name	<u>NMGF</u>	<u>US FWS</u>	Critical <u>Habitat</u>	<u>SGCN</u>	<u>Photo</u>
Canada Lynx	Lynx canadensis		T			No Photo
Bald Eagle	Haliaeetus leucocephalus	T			Υ	<u>View</u>
Peregrine Falcon	Falco peregrinus	T			Υ	<u>View</u>
Arctic Peregrine Falcon	Falco peregrinus tundrius	T				No Photo
<u>Least Tern</u>	Sternula antillarum	Е	Е		Υ	<u>View</u>
Yellow-billed Cuckoo (western pop)	Coccyzus americanus occidentalis		Т		Υ	<u>View</u>
Mexican Spotted Owl	Strix occidentalis lucida		Т	Υ	Υ	<u>View</u>
Costa's Hummingbird	Calypte costae	T			Υ	<u>View</u>
Southwestern Willow Flycatcher	Empidonax traillii extimus	Е	Е	Υ	Υ	<u>View</u>
Gray Vireo	Vireo vicinior	T			Υ	<u>View</u>
Zuni Bluehead Sucker	Catostomus discobolus yarrowi	Е	Е	Υ	Υ	<u>View</u>

- 1. Allium gooddingii
- 2. Echinocereus fendleri var. kuenzleri

#### Los Alamos

1. Lilium philadelphicum \*

#### Luna

- 1. Mammillaria wrightii var. wilcoxii \*
- 2. Opuntia arenaria
- 3. Peniocereus greggii

# **McKinley**

- 1. Allium gooddingii
- 2. Erigeron rhizomatus
- 3. Puccinellia parishii

#### Mora

1. None

#### Otero

- 1. Argemone pleiacantha subsp. pinnatisecta
- 2. Cirsium vinaceum
- 3. Cirsium wrightii
- 4. Echinocereus fendleri var. kuenzleri
- 5. Escobaria villardii
- 6. Hedeoma todsenii
- 7. Hexalectris nitida
- 8. Hexalectris spicata \*
- 9. Lepidospartum burgessii
- 10. Lilium philadelphicum \*

#### Quay

1. None

#### Rio Arriba

- 1. Sclerocactus cloveriae subsp. brackii
- 2. Spiranthes magnicamporum \*

#### Roosevelt

1. None

#### Sandoval

- 1. Lilium philadelphicum \*
- 2. Puccinellia parishii
- 3. Sclerocactus cloveriae subsp. brackii

#### San Juan

- 1. Alicella formosa
- 2. Allium gooddingii
- 3. Astragalus humillimus
- 4. Cypripedium parviflorum var. pubescens





Todsen's pennyroyal (Hedeoma todsenii)



Lee's pincushion cactus (Escobaria sneedii var. leei)



11/19/2018 Rare Plant List



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About the List History of Changes Species Considered, but dropped

Photographers, Illustrators and Authors Image Usage Guidelines Sponsors Discussion Group Useful Literature Links

# **Results of County Search**

MCKINLEY	
Scientific name	County-NM
Allium gooddingii	Catron, Lincoln, Mckinley, San Juan
Astragalus chuskanus	Mckinley, San Juan
Astragalus cliffordii	Mckinley, San Juan, Sandoval
Astragalus heilii	Mckinley
Astragalus micromerius	Mckinley, Rio Arriba, San Juan
Astragalus missouriensis var. accumbens	Catron, Cibola, Mckinley
Astragalus naturitensis	Mckinley, San Juan
Erigeron acomanus	Cibola, Mckinley
Erigeron rhizomatus	Catron, Mckinley, San Juan
Erigeron sivinskii	Mckinley
Eriogonum lachnogynum var. colobum	Mckinley, Taos
Eriogonum lachnogynum var. sarahiae	Mckinley
Mentzelia filifolia	Mckinley
Muhlenbergia arsenei	Mckinley, Sandoval, Santa Fe
Physaria navajoensis	Mckinley
Puccinellia parishii	Catron, Cibola, Grant, Hidalgo, Mckinley, San Juan, Sandoval
Senecio cliffordii	Mckinley, Rio Arriba

Photo credits in header *Peniocereus greggii* var. greggii © T. Todsen,

Lepidospartum burgessii © M. Howard, Argemone pleiacantha ssp. pinnatisecta © R. Sivinski

©2005 New Mexico Rare Plant Technical Council

County = Mckinley;

Tax Class	Family	Common Name	Scientific Name	Federal Status	State Status	GRank	SRank	Tracked	EOs	Info
Actinopterygii	Catostomidae	Bluehead Sucker	Catostomus discobolus discobolus			G4T4	S2	Yes	1	More Info
Actinopterygii	Catostomidae	White Sucker	Catostomus commersonii			G5	S5	No	2	More Info
Actinopterygii	Cyprinidae	Bonytail Chub	Gila elegans	LE		G1	SX	No	1	More Info
Actinopterygii	Cyprinidae	Roundtail Chub	Gila robusta	No federalstatus in NM	Е	G3	S2	Yes	1	More Info
Actinopterygii	Cyprinidae	Speckled Dace	Rhinichthys osculus	No federalstatus in NM		G5	S3	No	12	More Info
Amphibia	Hylidae	Boreal Chorus Frog	Pseudacris maculata			G5	S3	Yes	1	More Info
Aves	Accipitridae	Bald Eagle	Haliaeetus leucocephalus	No federalstatus in NM	Т	G5	S1B,S4N	Yes	2	More Info
Aves	Accipitridae	Golden Eagle	Aquila chrysaetos	No federalstatus in NM		G5	S3B, S4N	Yes	6	More Info
Aves	Charadriidae	Mountain Plover	Charadrius montanus	No federalstatus in NM		G3	S2B,S4N	Yes	3	More Info
Aves	Cuculidae	Yellow- Billed Cuckoo	Coccyzus americanus	LT		G5	S3B,S3N	Yes	5	More Info
Aves	Laniidae	Loggerhead Shrike	Lanius ludovicianus	No federalstatus in NM		G4	S3	No	1	More Info
Aves	Scolopacidae	Wilson's Phalarope	Phalaropus tricolor			G5	S2B, S4M	No	1	More Info
Aves	Strigidae	Mexican Spotted Owl	Strix occidentalis lucida	LT		G3G4T3T4	S2B,S2N	Yes	4	More Info
Aves	Tyrannidae	Southwestern Willow Flycatcher	Empidonax traillii extimus	LE	Е	G5T2	S1B,S1N	Yes	8	More Info
Dicotyledoneae	Apiaceae	Sessile- Flower False Carrot	Aletes sessiliflorus			G3	S3	No	1	More Info
Dicotyledoneae	Asteraceae	Clifford's Groundsel	Senecio cliffordii			GNR	S2	Yes	1	More Info
Dicotyledoneae	Asteraceae	Sacramento Groundsel	Senecio sacramentanus			G3	S3	Yes	1	More Info
Dicotyledoneae	Brassicaceae	Navajo Bladderpod	Physaria navajoensis	No federalstatus in NM		G2	S1	Yes	3	More Info
Dicotyledoneae	Fabaceae	Chaco Milkvetch	Astragalus micromerius			G3	S2S3	Yes	8	More Info
Dicotyledoneae	Fabaceae	Clifford's Milkvetch	Astragalus cliffordii			GNR	S1	Yes	2	More Info

Tax Class	Family	Common	Scientific	Federal	State	GRank	SRank	Tracked	EOs	Info
14.12 014.00		Name	Name	Status	Status				_ ~ ~	
Dicotyledoneae	Fabaceae	Naturita Milkvetch	Astragalus naturitensis	No federalstatus in NM		G2G3	S2	Yes	3	More Info
Dicotyledoneae	Fabaceae	Zuni Milkvetch	Astragalus accumbens	No federalstatus in NM		G3	S3	Yes	4	More Info
Dicotyledoneae	Polygonaceae	Clipped Wild Buckwheat	Eriogonum lachnogynum var. colobum			G4?T2	S2	Yes	3	More Info
Dicotyledoneae	Portulacaceae	Laguna Fame Flower	Talinum brachypodium			GNRQ	S1	Yes	1	More Info
Insecta	Coenagrionidae	Pacific Forktail	Ischnura cervula			G5	SNR	No	1	More Info
Insecta	Libellulidae	Western Pondhawk	Erythemis collocata			G5	SNR	No	1	More Info
Mammalia	Sciuridae	Gunnison's Prairie Dog	Cynomys gunnisoni	No federalstatus in NM		G5	S2	Yes	16	More Info
Monocotyledoneae	Poaceae	Navajo Muhly	Muhlenbergia arsenei			G5	S3	No	1	More Info

https://nhnm.unm.edu/bcd/print 2/2



# New Mexico Department of Agriculture

Office of the Director/Secretary MSC 3189 New Mexico State University P.O. Box 30005 Las Cruces, NM 88003-8005 575-646-3007

October 19, 2016

# **MEMORANDUM**

TO:

General Public

FROM:

Director/Secretary Jeff Witte

SUBJECT:

New Mexico Noxious Weed List Update

The Director of the New Mexico Department of Agriculture has selected the following plant species (see attached New Mexico Noxious Weed List) to be targeted as noxious weeds for control or eradication pursuant to the Noxious Weed Management Act of 1998.

Petitions to add new plant species to the state noxious weed list were solicited and received by the New Mexico Department of Agriculture (NMDA) from Cooperative Weed Management Areas, individuals, agencies, and organizations. The petitions were reviewed by the New Mexico Weed List Advisory Committee using ecological, distribution, impact, and legal status criteria within the State of New Mexico and adjoining states and countries. Based on their extensive knowledge and experience, experts from the New Mexico State University Plant Sciences Department added several species as well.

This list does not include every plant species with the potential to negatively impact the state's environment or economy. Landowners and land managers are encouraged to recognize plant species listed on the federal noxious weed list and other western states' noxious weed lists as potentially having negative impacts and to manage them accordingly.

# **New Mexico Noxious Weed List**

Updated September 2016

# **Class A Species**

Class A species are currently not present in New Mexico, or have limited distribution. Preventing new infestations of these species and eradicating existing infestations is the highest priority.

Common Name	Scientific Name
Alfombrilla	Drymaria arenariodes
Black henbane	Hyoscyamus niger
Brazillian egeria	Egeria densa
Camelthorn	Alhagi psuedalhagi
Canada thistle	Cirsium arvense
Dalmation toadflax	Linaria dalmatica
Diffuse knapweed	Centaurea diffusa
Dyer's woad	Isatis tinctoria
Giant salvinia	Salvinia molesta
Hoary cress	Cardaria spp.
Leafy spurge	Euphorbia esula
Oxeye daisy	Leucanthemum vulgare
Purple loosestrife	Lythrum salicaria
Purple starthistle	Centaurea calcitrapa
Ravenna grass	Saccharum ravennae
Scentless chamomile	Matricaria perforata
Scotch thistle	Onopordum acanthium
Spotted knapweed	Centaurea biebersteinii
Yellow starthistle	Centaurea solstitialis
Yellow toadflax	Linaria vulgaris

# **Class B Species**

**Common Name** 

Class B Species are limited to portions of the state. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread.

**Scientific Name** 

African rue	Peganum harmala
Bull thistle	Cirsium vulgare
Chicory	Cichorium intybus
Halogeton	Halogeton glomeratus
Malta starthistle	Centaurea melitensis
Perennial pepperweed	Lepidium latifolium
Poison hemlock	Conium maculatum

QuackgrassElytrigia repensRussian knapweedAcroptilon repensSpiny cockleburXanthium spinosumTeaselDipsacus fullonum

# **Class C Species**

Class C species are wide-spread in the state. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation.

# <u>Common Name</u> <u>Scientific Name</u>

Cheatgrass Bromus tectorum

Curlyleaf pondweed Potamogeton crispus

Eurasian watermilfoil Myriophyllum spicatum

Giant cane Arundo donax
Hydrilla Hydrilla verticllata
Jointed goatgrass Aegilops cylindrica
Musk thistle Carduus nutans

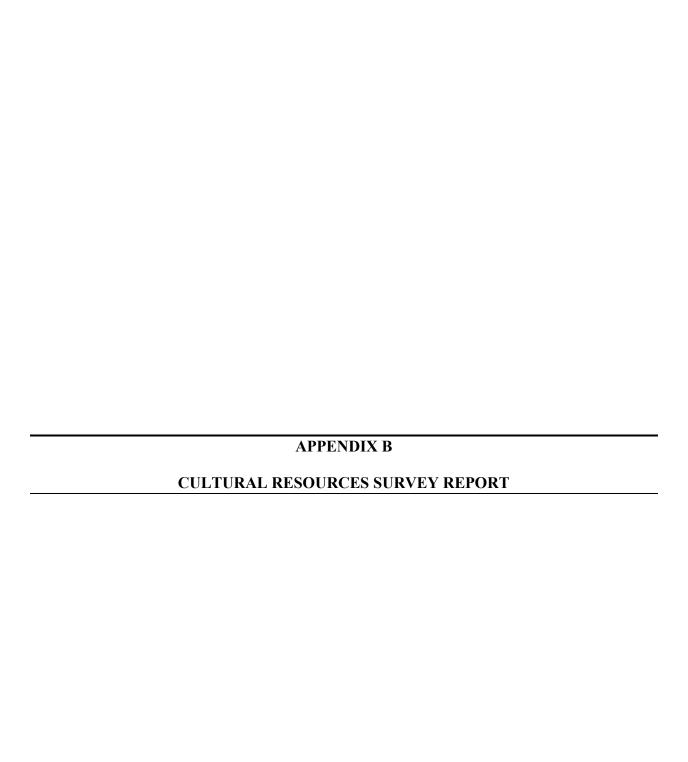
Parrotfeather Myriophyllum aquaticum Russian olive Elaeagnus angustifolia

Saltcedar Tamarix spp.
Siberian elm Ulmus pumila
Tree of heaven Ailanthus altissima

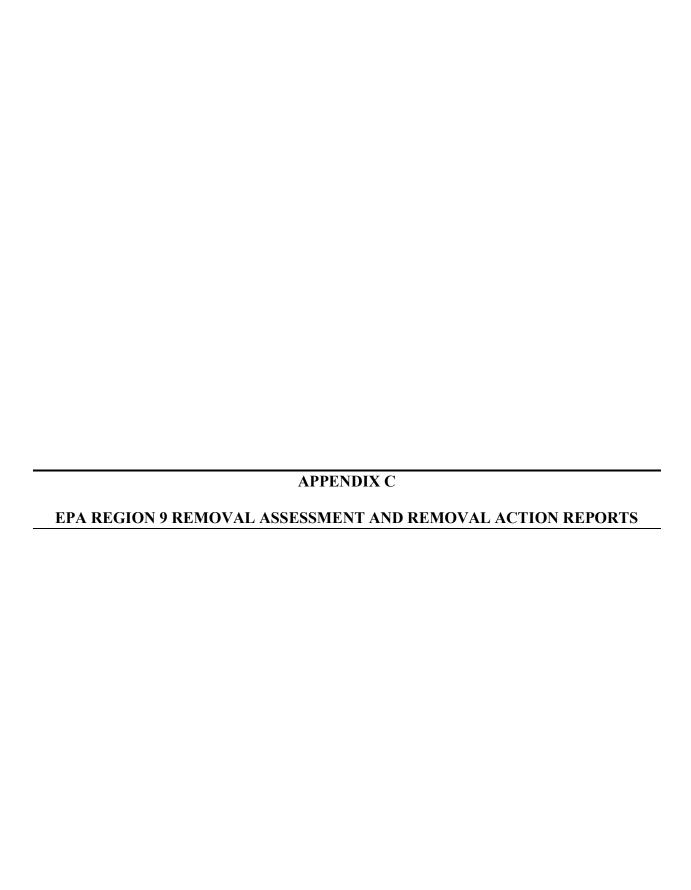
# **Watch List Species**

Watch List species are species of concern in the state. These species have the potential to become problematic. More data is needed to determine if these species should be listed. When these species are encountered please document their location and contact appropriate authorities.

Common Name	Scientific Name			
Crimson fountaingrass	Pennisetum setaceum			
Meadow knapweed	Centaurea pratensis			
Myrtle spurge	Euphorbia myrsinites			
Pampas grass	Cortaderia sellonana			
Sahara mustard	Brassica tournefortii			
Syrian beancaper	Zygophyllum fabago L.			
Wall rocket	Diplotaxis tenuifolia			



REDACTED DUE TO SENSITIVE CULTURAL CONCERNS BY THE NAVAJO NATION	r
TRIBAL HISTORICAL PRESERVATION OFFICER AND THE NEW MEXICO STATE	
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HISTORICAL PRESERVATION OFFICER."	



# Removal Assessment Report Tronox AUM Sections 32 and 33 Eastern Agency Prewitt, McKinley County, New Mexico

AUM Section 32 TDD No.: TO-02-09-11-10-0004

Project No.: EE-002693-2164-01TTO

**AUM Section 33** 

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

September 2012

#### **Prepared for:**

U.S. ENVIRONMENTAL PROTECTION AGENCY Region IX

Prepared by:

**ECOLOGY AND ENVIRONMENT, INC.** 

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### ist of Abbreviations and Acronyms

AUM Abandoned Uranium Mine

bgs below ground surface

cpm counts per minute

EML Environmental Measurements Laboratory

ERT Environmental Response Team

GIS Geographical Information System

GPS Global Positioning System

HASL Health and Safety Laboratory

hr/day hours per day

NNEPA Navajo Nation Environmental Protection Agency

pCi/g picocurie per gram

PIC pressurized ionization chamber PRG Preliminary Remediation Goal

QC quality control Ra-226 Radium-226

Ra-226+D Ra-226 and its radioactive decay chain products

 $\begin{array}{ccc} \text{rem} & \text{Roentgen equivalent man} \\ \text{r}^2 & \text{coefficient of determination} \end{array}$ 

SAP Sampling and Analysis Plan

SD standard deviation

sf square feet

START Superfund Technical Assessment and Response Team

USEPA United States Environmental Protection Agency

Weston Weston Solutions, Inc.

## 1 Introduction

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s Superfund Technical Assessment and Response Team (START) to conduct a removal assessment at Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico, in the Casamero Lake and Haystack Chapters of the Navajo Nation. AUMs 32 and 33 were part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA *et al.* 2008). The removal assessment included scanning gamma radiation activity in soil and waste piles, collecting samples from soil and waste piles, and assessing home sites near the AUMs. This report documents the field activities and results of the removal assessment.

## 2 Site Background

#### 2.1 Site Location

AUM 32 is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Figure 2-1). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation. The Chapter House is approximately 1.4 miles northwest of AUM 32. AUM 32 consists of a former mine area (Latitude: 35°29'26.7576"N, Longitude: -108°1'2.7798"W) and transfer area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W). The mine area is bordered to the east by AUM 33. The transfer area is located approximately 0.3 mile southwest of the mine area. AUM 32 is located in a range land.

AUM 33 is located immediately east of the AUM 32 mine area (Latitude: 35°29'26.1972"N, Longitude: -108°0'59.8583"W). AUM 33 is privately owned and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation. AUM 33 is located in a range land.

Two home sites are located 0.5 mile west of AUMs 32 and 33 and were also included as part of this assessment.

#### 2.2 Site Description

The AUM 32 mine area is approximately 365,005 square feet (sf) and contains an unsecured deep shaft located in the southeastern portion, and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The mine area is relatively flat with sparse vegetation. Available geographical information show an ephemeral stream or river located north and south of the mine area and converges approximately 0.25 mile west of the mine area. A 10-foot deep ditch was observed to run from east to west and bounded the mine area to the north. The ditch connects to a pond located northwest of the mine area.

The AUM 32 transfer area is approximately 267,432 sf and contains a concrete pad and a sealed vent (Appendix A). The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flows toward a northwest direction was observed (Appendix A).

AUM 33 has an approximate area of 153,963 sf and contains waste piles, a wooden hopper located in the northeastern corner, and an undetermined extent of underground workings (Weston 2009). AUM 33 is relatively flat with sparse vegetation. Available geographical information show an ephemeral stream or river located north and south of AUM 33 which converges approximately 0.25 mile to the west, and two ponds located on the northeast. Evidence of water flowing through the AUM was observed. The two ponds were observed to be filled with water.

Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during field activities detected bedrock at 3 feet below ground surface (bgs). No residences and public structures were found within 0.25 miles of AUMs 32 and 33. The nearest resident lives approximately 0.5 mile to the west. Agricultural food production such as livestock grazing or farming common in Navajo communities was not documented at or immediately adjacent to the AUMs; however, domestic pets, terrestrial wildlife, and animal droppings were observed.



The nearest residence consisted of two home sites. Home site CL-001 was composed of 3 structures (2 houses and a shed). Home site CL-002 was composed of 2 structures (a house and a hogan). Details on the home sites are provided in Appendix B.

#### 2.3 Site History

According to USEPA, portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore for national defense and energy purposes on Navajo tribal lands led to a legacy of AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

AUMs 32 and 33 contained historical mines which were reportedly owned by Cobb Nuclear Company and were closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations was available. No visible signs of reclamation were reported.

USEPA and Navajo Nation Environmental Protection Agency (NNEPA) interviewed a local resident who showed the location of a former transfer area southwest of the AUM 32 mine area. A concrete pad where a crane was reportedly mounted was located in the potential former transfer area. The resident had relatives who formerly worked for Cobb Nuclear Company and reported rail cars transported material from the mine area towards the south and southeast directions. The reported structures were not evident in historical aerial photographs available after the July 2012 USEPA-led field activities (Appendix C).

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The nearest residents reportedly used some materials (tarps and lumber) obtained from the mine (Weston 2009).

#### 2.4 Previous Investigation

A site screening was conducted at AUMs 32 and 33 which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the initial boundary of the mine areas and along two diagonal intersecting transects from the mine areas' four corners. Gamma radiation activity measurements ranged from 10,689 to 180,367 counts per minute (cpm) at AUM 32; and 14,322 to 140,917 cpm at AUM 33. A rock from a waste pile at AUM 33 emitted over 800,000 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 to 17,128 cpm. The building materials in the nearest residence had gamma radiation measurements of approximately 12,000 cpm.

#### 2.5 Removal Assessment Objective

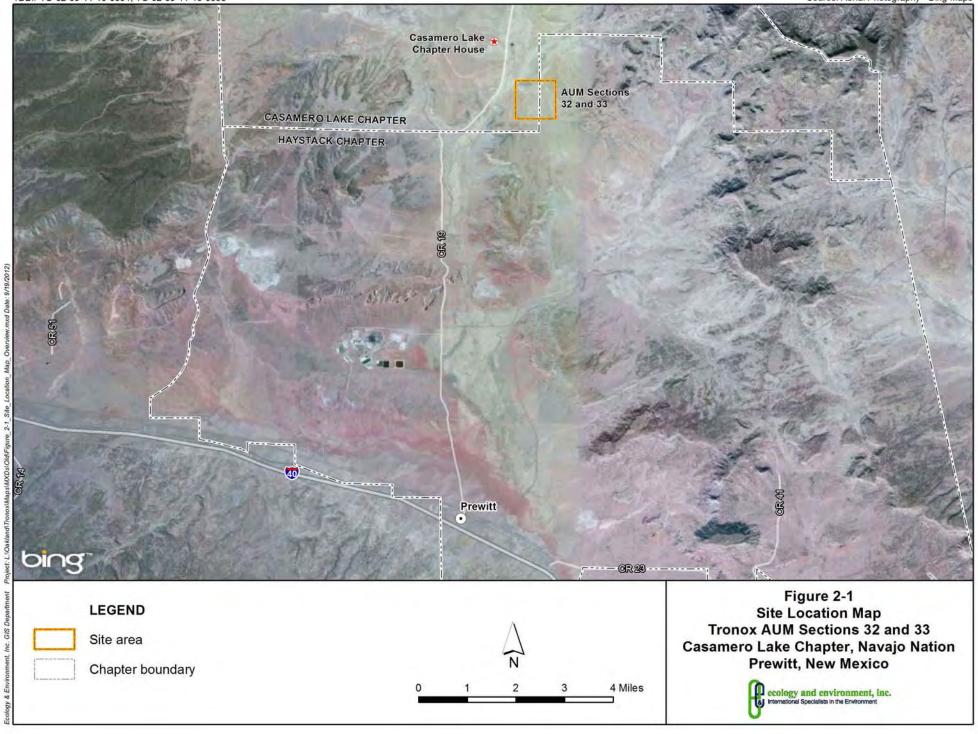
The AUMs are accessible and unsecured. Gamma radiation activity in surface soil and waste piles at the AUMs and in residential structures at the home sites may pose an imminent and substantial threat to human health. USEPA led a removal assessment to define the lateral and vertical extent of gamma radiation levels in soil, gamma radiation levels in the waste piles, and presence of radiation in the residential structures to determine whether a removal action at the AUMs is necessary to protect human health.





START prepared Sampling and Analysis Plans (SAP) with the following specific objectives for the removal assessment (Appendix D).

- 1. Determine whether, and in what areas, concentrations of Radium-226 (Ra-226) in surface soil require removal, further assessment, or no further action.
  - Determine whether gamma radiation activity readings can be used to characterize the AUMs or if further sampling to characterize the AUMs is necessary.
  - Determine a suitable background location for collecting data to calculate a site-specific action level or identify an alternate means of setting an action level.
- 2. Determine whether concentrations of Ra-226 in subsurface soil at locations where the surface levels of Ra-226 are elevated require removal, further assessment, or no further action.
- 3. Determine radiation levels at the home site.
  - Determine gamma exposure levels inside residential structure require removal of the structure or no further action.
  - Determine whether gamma radiation activity in floor surfaces and/or surface soil around the home site require removal or no further action.



## 3 START Field Activities

The field activities for the removal assessment consisted of two events. The first event was in June 2012 when START's planned activities included surface gamma radiation survey and sampling at AUM 32 mine area and AUM 33; and home site assessment. During the home site assessment, USEPA and NNEPA received information from the nearby resident about a potential former transfer area located southwest of the AUM 32 mine area. As a result, USEPA led an initial surface gamma radiation survey at the AUM 32 transfer area. The second event was in July 2012 when START conducted additional surface gamma radiation survey to delineate the AUM 32 transfer area and collected additional soil samples at the AUMs. Appendix A contains photographs of the field activities.

All field activities were conducted according to the SAP and SAP Addendum (Appendix D) except for subsurface sampling. During the June 2012 event, USEPA directed START to collect subsurface samples from one borehole instead of clustered boreholes because of soil conditions and feasibility in the field. During the July 2012 event, USEPA tasked START to collect additional subsurface samples at AUM 33 using a Geoprobe® system. The sample results are discussed in Section 4.0.

#### 3.1 June 2012

START mobilized to the AUMs on June 11, 2012. The USEPA On-Scene Coordinator, USEPA Environmental Response Team (ERT), and NNEPA were also on site. Field activities included surface gamma radiation survey at the background area, AUM 32, and AUM 33; soil sampling for Ra-226 analysis at the background area and the AUM 32 mine area; soil and waste pile sampling for Ra-226 analysis at AUM 33; and home site assessment. START demobilized on June 16, 2012.

#### 3.1.1 Surface Gamma Radiation Survey

A surface gamma radiation survey was conducted using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter. Operational checks were conducted on the paired meter and detector before the field activities using a Spectrum Techniques check source with 1 microcurie of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument was set using a Fluke voltage meter. An operational check was also conducted before each survey day.

The VIPER system and geographical information system (GIS) were used for geospatial information collection and analysis. The survey meters were linked to the VIPER system which stored the data throughout the collection period. Survey data was downloaded from the VIPER system at the end of each day and processed using GIS.

Surface gamma radiation surveys were conducted in the background area, AUM 32 mine and transfer area, and AUM 33. The radiation survey equipment was mounted 6 inches from the ground surface to measure gamma radiation activity in surface soil The survey was conducted at transects 3 feet apart at a pace of 3 feet per second. Step-outs were conducted at transects up to 6 feet apart. The transect width was based on the field of view of the detector which was 3 to 6 feet in diameter.



#### 3.1.1.1 Background Area

A background area was initially selected 600 feet southwest of AUM 32. After an interview with a nearby resident, a new background area was selected by the NNEPA and USEPA according to the *Background Location Selection Criteria* (NNEPA and USEPA 2010). The final background area was located 0.5 mile from AUMs 32 and 33 (Figure 3-1).

Gamma radiation activity was measured in the background area every day a survey was conducted at the AUMs or home sites according to the procedure outlined in the SAP (Appendix D). The mean and standard deviation (SD) of the gamma radiation activity measurements were calculated to determine if the background area was acceptable according to the SAP. The mean and SD were calculated and used to develop the investigation level. The investigation level was based on the mean plus 10 times the SD and was used to guide the field survey.

#### 3.1.1.2 AUM 32

The gamma radiation survey of surface soil at the mine area of AUM 32 consisted of 3-foot wide transects using a push cart covering 100 percent of the initial mine boundary and 6-foot wide transect step-outs until the gamma radiation activity level was below the investigation level. The step-outs extended to the west up to a dirt road running north to south and to the north up to a 10-foot deep ditch running east to west (Figure 3-1).

The gamma radiation survey of surface soil at the transfer area of AUM 32 consisted of 6-foot wide transects using a vehicle starting from the concrete pad and extending laterally in all directions until the gamma radiation activity level was below the investigation level.

#### 3.1.1.3 AUM 33

The gamma radiation survey of surface soil at AUM 33 consisted of 3-foot wide transects using a push cart covering 100 percent of the initial mine boundary and 6-foot wide transect step-outs until the gamma radiation activity level was below the investigation level. The waste piles were scanned by holding the meter 6 inches from the surface of the waste pile and moving in a serpentine motion at a scan rate of 1 to 2 feet per second covering 100 percent of the waste pile.

#### 3.1.2 Sampling for Ra-226 Analysis

Soil and waste pile samples were collected for Ra-226 analysis. Soil samples were collected from the background area, AUM 32 mine area, and AUM 33. Waste pile samples were collected from AUM 33. Surface static 1-minute gamma radiation activity was also measured at the soil sampling locations to determine the relationship between gamma radiation activity level and Ra-226 concentration in surface soil.

#### 3.1.2.1 Background Area

Surface soil samples were collected from 0 to 2 inches bgs at random locations within the background area using a stainless steel trowel and placed in a 4-ounce plastic jar. The random locations were determined using Visual Sampling Plan software version 6.2 (Appendix D). Nonsoil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 11 surface soil samples were collected from the background area.



#### 3.1.2.2 AUM 32

Surface soil locations at the AUM 32 mine area were determined based on the results of the gamma radiation survey. Surface soil sample locations were located at the mine area using a Global Positioning System (GPS) unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The surface soil locations are shown in Figure 3-1. Surface soil sampling procedures were similar to the background area. A total of 25 surface soil samples were collected from the AUM 32 mine area.

Subsurface soil samples were collected from locations of the highest gamma radiation activity results based on the 100 percent scan of the AUM 32 mine area. Subsurface soil sample locations were located at the mine area using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The subsurface soil locations are shown in Figure 3-1. Soil samples were collected at 1-foot depth intervals from the ground surface down to 3 feet bgs. Subsurface samples were collected using a hand auger and placed in a 4-ounce plastic jar. Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 27 subsurface soil samples were collected from the AUM 32 mine area.

#### 3.1.2.3 AUM 33

Surface soil locations at AUM 33 were determined based on the results of the gamma radiation survey. Surface soil sample locations were located at AUM 33 using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The surface soil locations are shown in Figure 3-1. Surface soil sampling procedures were similar to the background area. A total of 16 surface soil samples were collected from AUM 33.

Subsurface soil samples were collected from locations of the highest gamma radiation activity results based on the 100 percent scan of AUM 33. Subsurface soil sample locations were located at AUM 33 using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag. The subsurface soil locations are shown in Figure 3-1. Soil samples were collected at 1-foot depth intervals from the ground surface down to 3 feet bgs except at AUM33-06 where the deepest sample was collected at 34 inches bgs due to refusal. Subsurface samples were collected using a hand auger and placed in a 4-ounce plastic jar. Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. All sample locations were recorded in the field logbook. A total of 21 subsurface soil samples were collected from AUM 33.

A surface sample (0 to 2 inches bgs) was collected from each waste pile to represent the lowest, middle of the range, and highest gamma radiation activity detected in the three waste piles. Surface waste pile samples were collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. The waste pile samples were recorded and shipped with the soil samples. A total of 3 samples were collected from the waste piles.

#### 3.1.2.4 Quality Control

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability (Appendix D). A total of eight duplicate samples were collected.

Sampling equipment was decontaminated after every sample. One rinsate sample was collected from each equipment at the end of each sampling day to assess field contamination. Six



equipment rinsate samples and one sample of the distilled water used for the equipment rinsate were collected.

Sample jars were stored in a cooler according to the laboratory requirements and shipped at the end of field activities to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina. Chain-of-custody forms were completed and sent with the sample shipment. The samples were analyzed for Ra-226 by Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (Department of Energy 1990). Tier 1 data validation was conducted by the laboratory and Tier 2 data validation was performed by START according to the USEPA guidance (USEPA 1990 and 2001).

#### 3.1.3 Home Site Assessment

Home site assessment was conducted at two home sites – CL-001 and CL-002. NNEPA and USEPA obtained access agreements from the residents. The home site assessment consisted of background measurements for each radiation instrument, surface gamma radiation survey inside and outside the structures, and gamma radiation exposure rate measurements inside the structures.

A background measurement for each radiation instrument was collected prior to commencing the home site assessment. Three sample locations generally located within 20 feet of each other were selected and marked at the background area. At each location, a General Electric Reuter-Stokes High Pressurized Ionization Chamber RSS 131 (PIC) was used to measure and record the gamma radiation exposure rate in milliRoentgen per hour once per second for approximately 5 minutes. The PIC measurements were collected to determine the average exposure rate within a background area. To allow the instrument to reach its full-scale measurement range, and to account for the period when personnel were near the machine (i.e., turning the PIC on or off), data collected in the first or last 90 seconds of the 5 minute PIC sample period was not used. The PIC sampling method was based on recommendations from the manufacturer to: (1) minimize movement around the instrument during sampling to help prevent undesirable changes in the static radiation field; and, (2) omit instrument fluctuations at the beginning and end of a sampling period; and was consistent with previous Navajo home site assessments. After omitting the approximate first 90 measurements, the next 120 measurements were used to calculate the average exposure rate at each location which was used to estimate the average background exposure rate. Background measurements were performed for the gamma radiation survey equipment by scanning the perimeter of the background area for a minimum of 3 minutes to collect at least 180 data points.

START conducted gamma radiation survey of surface soil similar to the procedures in Section 3.1.1 around each structure covering 100 percent of the property. Gamma radiation activity was also measured inside each structure using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter held 6 inches above the floor, and moved in a serpentine motion at a scan rate of 1 to 2 feet per second. Transects were surveyed from one wall to the opposite wall until 100 percent of the accessible areas were scanned. Objects encountered during the survey were not moved, and the survey was performed around the object. The extent of the elevated measurements was determined and the dimensions of the elevated area were documented on a sketch of the area on a structure diagram. The approximate average gamma radiation activity was recorded for each room in the structure. All measurements were documented on a survey form. Static exposure rate measurements were collected inside each room of every accessible structure. In the center of



each room, or closest location if obstructed, a PIC was placed 1 meter above the floor, and measurements were collected every second and logged for 5 minutes. The PIC measurements were collected to represent the statistically-based average exposure rate in each room. The exposure rate was used to determine the dose to a resident if the room were occupied, for comparison to dose risk ranges. Each structure was photographed and included in the home site packet (Appendix B).

#### 3.2 July 2012

START re-mobilized to the AUMs on July 16, 2012 to further assess the AUM 32 transfer area. START's planned field activities included additional surface gamma radiation survey and soil sampling for Ra-226 analysis at the transfer area at AUM 32. During the field activities, USEPA directed START to collect additional subsurface soil samples for Ra-226 analysis at AUMs 32 and 33 using a Geoprobe® system. START demobilized on July 20, 2012.

#### 3.2.1 Surface Gamma Radiation Survey

An additional gamma radiation survey of surface soil at the AUM 32 transfer area was conducted. Operational checks were performed similar to the June 2012 event. The same paired Ludlum Model 44-20 (3x3) detector and 2241 meter were used with the VIPER and GIS systems. According to the SAP Addendum (Appendix D) the survey equipment was mounted 6 inches from the ground surface on a vehicle and transects were conducted 3 to 5 feet apart at a pace of 3 feet per second at all accessible areas. The transect width was based on the field of view of the detector which was 3 to 6 feet in diameter. Step-outs were conducted until readings were below the investigation level.

#### 3.2.2 Sampling for Ra-226 Analysis

Soil samples were collected at the AUM 32 transfer area for Ra-226 analysis. Additional subsurface samples were collected from the AUM 32 and AUM 33 mine areas. Surface static 1-minute gamma radiation activity was also measured at the soil sampling locations as additional data for determining the relationship between gamma radiation activity level and Ra-226 concentration in surface soil.

#### 3.2.2.1 AUM 32

Sampling locations were determined based on the results of the gamma radiation survey (Figure 3-1). Sampling locations were marked and surface soil was sampled similar to the June 2012 event. A total of 24 surface soil samples were collected from the AUM 32 transfer area.

Subsurface samples were collected at the AUM 32 transfer area using a Geoprobe® system according to the SAP Addendum (Appendix D). Navajo Tribal Utility Authority cleared the area of known utilities. In addition, utility location was conducted at all of the boring locations by Pacific Coast Locators, Inc. on July 17, 2012. All locations were cleared within an 8- by 8-foot area and down to 6 feet bgs for drilling. A continuous core was extracted down to 3 feet bgs. Soil boring logs were documented by the START geologist. Subsurface samples from one location (AUM32-49) were collected using a hand auger down to 24 inches bgs due to refusal. A total of 46 subsurface soil samples were collected from the AUM 32 transfer area.

Additional subsurface soil samples were collected from the AUM 32 mine area at locations where previous Ra-226 concentrations detected at 3 feet bgs exceeded the action level. AUM32-01, -08, and -09 were cleared by the utility locator and samples were collected at 3 and 4 feet bgs





from the soil core extracted using a Geoprobe® system. A total of 6 additional subsurface soil samples were collected from the AUM 32 mine area.

#### 3.2.2.2 AUM 33

Additional sampling at AUM 33 using a Geoprobe® system was tasked by USEPA during the field activities for AUM 32. The utility locator cleared 3 boring locations within an 8- by 8- foot area down to 6 feet bgs for drilling. Only one location was accessible with the Geoprobe® truck. A continuous core was extracted down to 4 feet bgs from AUM33-07 (Figure 3-1). Soil boring logs were documented by the START geologist. A soil sample was collected at 3 and 4 feet bgs from the soil core. A total of 2 additional subsurface soil samples were collected from AUM 33.

#### 3.2.2.3 Quality Control

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability (Appendix D). A total of seven duplicate samples were collected.

Sampling equipment was decontaminated after every sample. One rinsate sample was collected from each equipment at the end of the sampling day to assess field contamination. Five equipment rinsate samples and one sample of the distilled water used for the equipment rinsate were collected.

Sample jars were stored in a cooler according to the laboratory requirements and shipped at the end of field activities to GEL Laboratories, LLC. Chain-of-custody forms were completed and sent with the sample shipment. The samples were analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method (Department of Energy 1990). Tier 1 data validation was conducted by the laboratory and Tier 2 data validation was performed by START according to USEPA guidance (USEPA 1990 and 2001).

Project # EE-002693-2164-01TTO, EE-002693-2165-01TTO TDD# TO-02-09-11-10-0004, TO-02-09-11-10-0005 Open mine shaft GASAMERO LAKE

# **LEGEND** Figure 3-1 Gamma activity levels Soil Sampling Location Map Tronox AUM Sections 32 and 33 in kilo counts per minute Sample location type Initial mine area Less than or equal to Investigation Level (0 - 40) Subsurface Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico Transfer area Greater than Investigation Level (40.1 - 50) Surface Homesite 400 800 Feet Greater than 2x Background Level (50.1 - 240) ecology and environment, inc. International Specialists in the Environment Chapter boundary Background area Greater than 10x Background Level (>240)

## 4 Results

The results of the surface gamma radiation survey, soil and waste pile sampling, and home site assessment are presented below. The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and proposed removal areas are also presented in this section.

#### 4.1 Surface Gamma Radiation Survey

#### 4.1.1 Background Area

The results of the surface gamma radiation survey in the background area are shown in Figure 3-1. The background area had a low daily mean and SD and was considered acceptable according to the SAP (Appendix D). The calculated mean background gamma radiation activity ranged from 23,706 to 23,870 cpm and the SD ranged from 141 to 330 cpm. The highest investigation level developed using the daily mean and SD of the gamma radiation activity measured in the background area was 27,011 cpm which was used as the initial investigation level in the field. A new investigation level was developed based on the relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements (Section 4.4).

#### 4.1.2 AUM 32

The results of the surface gamma radiation survey at the AUM 32 mine area are shown in Figure 4-1. Gamma radiation activity ranged from 38,560 to 962,400 cpm. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm.

Step-outs of the gamma radiation survey was conducted in all directions of the initial mine boundary except for the eastern boundary which was immediately bordered by AUM 33. An open shaft located in the southeastern portion of the mine area was demarcated at least 10 feet around the opening and not surveyed for protection of health and safety. The gamma radiation survey extended 200 feet north of the initial mine boundary up to a 10-foot deep ditch. A hand-scan of the bottom of the ditch did not indicate elevated levels. The gamma radiation survey extended 100 feet south and 1,000 feet west of the initial mine boundary. The total mine area surveyed was 489,851 sf.

The results of the surface gamma radiation survey at the AUM 32 transfer area are shown in Figure 4-2. Gamma radiation activity ranged from 16,880 to above 1,000,000 cpm. The highest reading recorded by the VIPER system was 24,000,000 cpm. The total transfer area surveyed was 2,010,910 sf.

#### 4.1.3 AUM 33

The result of the surface gamma radiation survey at AUM 33 is shown in Figure 4-3. Gamma radiation activity ranged from 33,410 to above 1,000,000 cpm. The highest reading recorded by the VIPER system was 4,221,540 cpm. The total area surveyed was 173,956 sf.

#### 4.2 Sampling for Ra-226 Analysis

All analytical results were validated and found to be acceptable to meet project objectives for use as definitive-level data without qualification. Validated analytical results are included in Appendix E.



#### 4.2.1 Background Area

Surface soil samples were collected from random locations within the background area. The sample results and co-located 1-minute gamma radiation activity measurements are presented in Table 4-1. The background Ra-226 concentrations ranged from 0.592 to 0.900 picocuries per gram (pCi/g). The highest Ra-226 background concentration of 0.900 pCi/g was used to calculate the action level for the AUMs.

The action level for Ra-226 was based on the sum of the highest background concentration of Ra-226 and the USEPA Preliminary Remediation Goal (PRG) of 1.21 pCi/g (USEPA 2010). The action level for Ra-226 in soil at the AUMs is 2.11 pCi/g.

#### 4.2.2 AUM 32

The sample results (AUM32-01 through -25) and co-located 1-minute gamma radiation activity measurements from the AUM 32 mine area are presented in Table 4-2. Ra-226 concentrations in surface soil at the mine area ranged from 1.19 to 37.3 pCi/g. Ra-226 concentrations detected down to 4 feet bgs in subsurface soil ranged from 0.797 to 112 pCi/g. AUM32-01, -08, and -09 contained elevated concentrations of Ra-226 at 3 feet bgs and were re-sampled at 3 and 4 feet bgs using a Geoprobe® system. The results from samples obtained using a hand auger decreased by an average of 79% when samples were collected using a Geoprobe®. The Geoprobe® method is considered to collect more representative samples at each depth; therefore, the Geoprobe® results were used. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-1. Soil around the open shaft in the mine area contained Ra-226 concentrations above the action level down to depths of 2 to 3 feet bgs. The remainder of the mine area showed Ra-226 concentrations above the action level in surface soil and down to depths of 1 to 2 feet bgs except for AUM-32-04 which slightly exceeded the action level at 3 feet bgs.

The sample results (AUM32-26 through -49) and co-located 1-minute gamma radiation activity measurements from the AUM 32 transfer area are presented in Table 4-2. Ra-226 concentrations in surface soil at the transfer area ranged from 0.789 to 300 pCi/g. Ra-226 concentrations detected down to 3 feet bgs in subsurface soil ranged from 0.544 to 94.8 pCi/g. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-2. Soil in the area with gamma radiation activity of above 1 million cpm during the survey contained Ra-226 concentrations of 237 to 300 pCi/g in surface soil as detected in sampling locations AUM32-27, -28, and -29. Ra-226 concentrations in sampling locations AUM32-27 and -28, were above the action level down to 1 foot bgs. AUM32-29 had elevated levels of Ra-226 down to 3 feet bgs. AUM32-49 located between the mine and transfer areas contained 108 pCi/g of Ra-226 in surface soil and concentrations exceeding the action level down to 2 feet bgs where refusal was met using a hand auger. Except for these four sampling locations, elevated levels of Ra-226 in the transfer area were limited to surface soil (0 to 2 inches bgs). The southern portion of the transfer area was bounded by Ra-226 concentrations below the action level.

#### 4.2.3 AUM 33

The sample results (AUM33-01 through -16) and co-located 1-minute gamma radiation activity measurements from AUM 33 are presented in Table 4-3. Ra-226 concentrations in surface soil at AUM 33 ranged from 0.996 to 76.1 pCi/g. Ra-226 concentrations detected down to 3 feet bgs in subsurface soil ranged from 0.816 to 35.4 pCi/g. The soil depths of Ra-226 concentrations exceeding the action level are shown in Figure 4-3. AUM33-02, -04, and -07 contained elevated concentrations of Ra-226 at 3 feet bgs based on hand-augered samples (Table 4-3). Only



AUM33-07 was accessible with the Geoprobe® truck and was re-sampled at 3 and 4 feet bgs. The results from samples obtained using a hand auger decreased by 70% when samples were collected using a Geoprobe®. The Geoprobe® method is considered to collect more representative samples at each depth; therefore, the Geoprobe® results were used. Ra-226 concentrations detected at areas with gamma radiation activity above twice the background level exceeded the action level. All the waste pile samples (AUM33-WP-01, -02, and -03) exceeded the action level. Ra-226 concentrations detected around the waste piles were above the action level down to a depth of 2 feet bgs. The eastern and southern portions of AUM 33 were bounded by Ra-226 concentrations below the action level.

#### 4.3 Soil Geology

Soil borings using a Geoprobe® showed that, in general, soil at the AUMs consisted of clayey and sandy silt overlying shallow bedrock. Bedrock, as observed in most of the borings, consisted of weathered sandy siltstone and weathered siltstone at depths of 1 to 7.5 feet below bgs. Bedrock was not encountered at the total explored depth of four feet bgs at boring locations AUM32-01, AUM32-08, AUM32-09, AUM32-30, and AUM32-37. Obvious fill was noted at boring locations AUM32-01 and AUM32-08, where mine waste was observed at the ground surface. The total thickness of mine waste at boring locations AUM32-01 and AUM32-08 was observed to be 1 foot and 3 feet, respectively. Logs of soil stratigraphy for soil borings collected in July 2012 are included in Appendix F.

# 4.4 Relationship between Gamma Radiation Activity and Ra-226 Concentration

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated to determine if gamma radiation activity measurements can be used as a field screening tool to estimate Ra-226 concentrations. Gamma radiation activity can be measured in real-time in the field while Ra-226 concentrations are determined by laboratory analysis which takes months after sampling.

Correlation analysis measures the strength of association between the paired quantitative variables in the form of a correlation coefficient. The value of a correlation coefficient ranges from -1 for perfect negative correlation, to zero for no correlation at all, to +1 for a perfect positive correlation. The equation for the correlation coefficient is:

$$Correl(X,Y) = \frac{\sum (x - \overline{x})(y - \overline{y})}{\sqrt{\sum (x - \overline{x})^2 \sum (y - \overline{y})^2}}$$

Where:

*x*,*y* is the paired (co-located) 1-minute gamma radiation activity measurement and Ra-226 sample result from surface soil

 $\bar{x}$  is the mean of the 1-minute gamma radiation activity measurements

 $\overline{y}$  is the mean of the Ra-226 sample results

The correlation coefficient calculated from all surface soil data using Excel (Microsoft 2010) was 0.77 (Table 4-4). The data was further divided into subsets to refine the correlation. The results indicate correlation increased based on data less than 60,000 cpm, equipment used, and



absence of subsurface gamma radiation activity. The highest correlation coefficient was 0.92 which was calculated from the gamma radiation activity measurements using equipment A1.

Linear regression analysis was also conducted to determine if the relationship between colocated 1-minute gamma radiation activity and Ra-226 concentration in surface soil may be predicted by the linear equation y=mx+b.

#### Where:

y is the predicted Ra-226 concentration m is the slope of the line x is the measured 1-minute gamma radiation activity b is the y-intercept of the line

Linear regression analysis was conducted using Excel (Microsoft 2010) which determined the linear least squares curve that best fits the paired data and calculated the coefficient of determination  $(r^2)$ . The  $r^2$  compares estimated and actual y values, and ranges in value from 0 to 1. If  $r^2$ =1, there is a perfect correlation in the sample; i.e., there is no difference between the estimated y value and the actual y value. If  $r^2$ =0, the regression equation is not helpful in predicting a y value. Similar to the correlation coefficient, the  $r^2$  was calculated for each data set (Table 4-4). The highest  $r^2$  was 0.84 which was calculated from the gamma radiation activity measurements using equipment A1. Figure 4-4 shows the predicted Ra-226 concentration based on the best-fit linear equation ( $r^2$ =0.84) and the measured Ra-226 concentration from the soil samples. Ra-226 concentrations cannot be predicted by the measured co-located 1-minute gamma radiation activity based on a linear trend.

The mean Ra-226 concentrations detected in surface soil within 5,000 cpm range increments of gamma radiation activity measurements were plotted per equipment to determine if gamma radiation activity measurements from each equipment pair can be used to determine if co-located Ra-226 concentrations are below the action level of 2.11 pCi/g (Figure 4-5). The graph shows the mean Ra-226 concentrations for co-located 1-minute gamma radiation activity measurements below 40,000 cpm using equipment A1 was below the action level. The 95% confidence interval of the mean calculated using Excel (Microsoft 2010) was 1.23 to 1.81 pCi/g.

The results indicate there is a correlation between surface soil Ra-226 sample results and colocated 1-minute gamma radiation activity measurements; however, gamma radiation activity measurements may be affected by equipment used, subsurface radiation activity, and other factors that result in a non-linear relationship with Ra-226 concentrations in surface soil. Locations with gamma radiation activity measurements below 40,000 cpm using equipment A1 will likely have mean surface soil concentrations of Ra-226 below the action level of 2.11 pCi/g.

#### 4.5 Home Site Assessment

The average exposure rate at the background area and the PIC measurements from each room in the structures at CL-001 and CL-002 are presented in Tables 4-5 and 4-6, respectively. Because the PIC only measures gamma radiation, a 1:1 conversion factor was assumed when converting the PIC measurements from Roentgen to a dose number, Roentgen equivalent man (rem), to estimate the average annual gamma radiation dose rate to a person spending 24 hours per day (hr/day) in the background area. Based on USEPA guidance, an excess cancer risk of  $3x10^{-4}$  was



used to calculate the acceptable dose above background. This calculation assumed that persons are occupying the room being assessed (and thus being exposed) for 24 hr/day, 365.25 days per year, for 30 years. The risk calculation is based on a risk conversion factor of 7% cancer incidence per 100 rem of exposure and comes from the National Academy of Sciences report on the Health Effects of Biological Exposure to Low Levels of Ionizing Radiation (National Research Council 1990). Based on this excess cancer rate, the allowable difference between the annual background dose rate and the annual dose rate for a person in the room being assessed was calculated as 15 mrem/yr. This calculated dose rate is consistent with Navajo projects in USEPA Region 9.

The difference between the background dose rate and the measured dose rate in each room in the structures at CL-001 and in the living room of structure B at CL-002 was negative (i.e. the resident would receive a greater dose in the background area). This result suggests that in most cases the structure is shielding the occupant from naturally-occurring background radiation. The difference between the background dose rate and the measured dose rate in the remaining rooms measured at CL-002 did not exceed 15 mrem/yr.

Results of the gamma radiation survey inside the structures and of surface soil outside the structures within the property were below the investigation level or twice the background level.

The results of the home site assessment were summarized in a home site packet which contained a table of interior measurements accompanied by a figure(s) with a scaled illustration of the structure and radiation measurements within the structures, a figure showing the results of the gamma radiation survey of surface soil around the structures and within the property, and a photographic log for each structure. The home site packet is included as Appendix B.

#### 4.6 Proposed Removal Areas

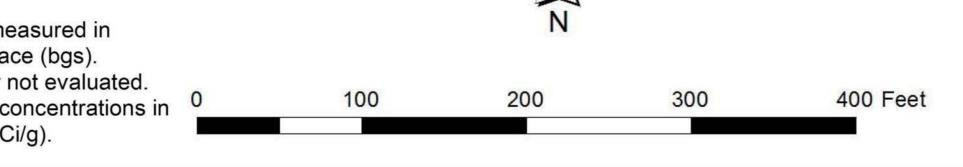
The results of the removal assessment defined areas of AUMs 32 and 33 for further action such as soil removal to protect human health. The proposed lateral extent of soil for removal was determined based on the surface gamma radiation activity levels and surface soil sample results exceeding the action level. Subsurface soil sample results exceeding the action level were used to determine the vertical extent of soil for removal. As directed by USEPA, the proposed removal areas were based on the most conservative estimate. The proposed removal areas for AUM 32 mine area are shown in Figure 4-6, AUM 32 transfer area in Figures 4-7 and 4-8, and AUM 33 in Figure 4-9. Table 4-7 presents the estimated soil excavation volumes by removal area. At AUM 32, a total of 27,009 cubic yards of soil was calculated for removal at the mine area and 18,043 cubic yards of soil was calculated for removal at the transfer area. A total of 18,556 cubic yards of soil was calculated for removal at AUM 33 excluding the waste piles. The proposed removal areas at the AUMs have a total excavation volume of 63,608 cubic yards of soil.

# Greater than Investigation Level (40.1 - 50) Greater than 2x Background Level (50.1 - 240) Greater than 10x Background Level (>240)

Greater than Action Level

Chapter boundary

# feet below ground surface (bgs). NE = Not applicable or not evaluated. Radium-226 (Ra-226) concentrations in 0 picocuries per gram (pCi/g).



**Prewitt, New Mexico** 



Project # EE-002693-2165-01TTO TDD# TO-02-09-11-10-0005 Source: Aerial Photography - Bing Maps AUM33-08 Depth Ra-226 AUM33-02 Depth Ra-226 AUM33-13 20.30 Depth Ra-226 4.07 6.00 AUM33-03 Depth Ra-226 AUM33-10 Depth Ra-226 AUM33-09 Depth Ra-226 AUM33-12 Depth Ra-226 AUM33-05 Depth Ra-226 **AUM33-11** 9.13 Depth Ra-226 4.61 AUM33-04 Depth Ra-226 AUM33-16 76.10 Depth Ra-226 35.40 19.00 Depth Ra-226 AUM33-01 Depth Ra-226 AUM33-07 1.04 1.05 AUM33-06 Depth Ra-226 AUM33-14 CASAMERO LAKE HAYSTACK Depth Ra-226 0.82 1.01 Figure 4-3 **LEGEND** Gamma Radiation Activity and Ra-226 Gamma activity levels **Ra-226 Concentration Soil Concentrations at AUM 33** in kilo counts per minute Note: in Surface Soil (0 to 2 inches bgs) **Tronox AUM Sections 32 and 33** Less than or equal to Investigation Level (0 - 40) Sample depths were measured in Less than or equal to Action Level (2.11 pCi/g) Casamero Lake Chapter, Navajo Nation feet below ground surface (bgs). **Prewitt, New Mexico** Greater than Investigation Level (40.1 - 50) Greater than Action Level NE = Not applicable or not evaluated. Greater than 2x Background Level (50.1 - 240) 300 400 Feet 100 Radium-226 (Ra-226) concentrations in 0 ecology and environment, inc.
International Specialists in the Environment Chapter boundary picocuries per gram (pCi/g). Greater than 10x Background Level (>240)

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Sections 32 and 33 Background Area

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

	Ra-226 Concentration <sup>b</sup>	Surface Gamma Radiation Activity <sup>c</sup> (cpm Radiation Survey Equipment <sup>d</sup>	
Sample ID <sup>a</sup>	(pCi/g)	A1	В2
Tronox - BKG2 - 01			
110110X - BKG2 - 01	0.666	24,087	24,000
Tronox - BKG2 - 02	0.592	23,534	23,892
Tronox - BKG2 - 03	0.801	23,497	23,719
Tronox - BKG2 - 04	0.900		
Tronox - BKG2 - 05	0.648		
Tronox - BKG2 - 06	0.740		
Tronox - BKG2 - 07	0.701		
Tronox - BKG2 - 08	0.722		
Tronox - BKG2 - 09	0.728		
Tronox - BKG2 - 10	0.698		
Tronox - BKG2 - 11	0.626		

#### Notes:

a	All background samples were collected from the surface		
	(0 to 2 inches below ground surface).		
b	Concentrations shown in <b>bold</b> exceed the action level of 2.11 pCi/g		
С	Static 1-minute measurement at sampling location		
d	Paired radiation survey equipment which consisted of Ludlum		
	Model 44-20 (3x3) detector and 2241 meter:		
	Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844)		
	and an Alpha Spectra detector (Serial No. 121611BP).		
	Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852)		
	and an Alpha Spectra detector (Serial No. 121611BQ).		

AUM	Abandoned uranium mine
cpm	Counts per minute
pCi/g	Picocuries per gram
Ra-226	Radium-226

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

100 No 10-02-09-11-10-0			EE-002095-2104-01110
	Ra-226	Surface Gamma	
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>
Mine Area <sup>e</sup>			
AUM32-01-02	10.2		
AUM32-01-12	8.86		
AUM32-01-24	4.50		
AUM32-01-36	6.18		
AUM32-01-36 (G)	1.35		
AUM32-01-48 (G)	1.24		
AUM32-02-02	2.89	42,213	B2
AUM32-02-12	2.09		
AUM32-02-24	2.47		
AUM32-02-36	1.98		
AUM32-102-36	2.51		
AUM32-03-02	8.21	54,245	B2
AUM32-03-12	2.94		
AUM32-103-12	2.67		
AUM32-03-24	1.98		
AUM32-03-36	1.40		
AUM32-04-02	12.4	73,533	B2
AUM32-04-12	2.58		
AUM32-04-24	1.45		
AUM32-04-36	2.15		
AUM32-05-02	2.07	74,440	B2
AUM32-05-12	2.12		
AUM32-05-24	1.39		
AUM32-05-36	1.42		
AUM32-06-02	22.2	104,554	B2
AUM32-06-12	1.14		
AUM32-06-24	1.62		
AUM32-106-24	2.01		
AUM32-06-36	1.49		
AUM32-07-02	1.65	106,041	B2
AUM32-07-12	12.8		
AUM32-07-24	31.0		
AUM32-07-36	40.7		
AUM32-08-02	37.3	492,811	В2
AUM32-08-12	112	,	
AUM32-08-24	9.78		
AUM32-08-36	10.8		

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

1DD No 10-02-09-11-10-0004		Project No.: EE-002693-2164-01110		
	Ra-226	Surface Gamma		
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey	
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>	
AUM32-08-36 (G)	2.45			
AUM32-08-48 (G)	1.07			
AUM32-09-02	2.41	183,333	B2	
AUM32-09-12	50.7			
AUM32-09-24	57.1			
AUM32-09-36	4.59			
AUM32-09-36 (G)	0.797			
AUM32-09-48 (G)	1.18			
AUM32-10-02	8.98	59,729	A1	
AUM32-11-02	1.36	68,578	A1	
AUM32-111-02	1.25	68,578	A1	
AUM32-12-02	1.19	64,143	A1	
AUM32-13-02	2.07	86,820	A1	
AUM32-14-02	1.37	32,594	A1	
AUM32-15-02	13.5	77,649	A1	
AUM32-16-02	3.20	44,563	A1	
AUM32-17-02	7.88	55,612	A1	
AUM32-18-02	10.0	58,320	A1	
AUM32-19-02	2.02	36,800	A1	
AUM32-20-02	16.6	66,519	A1	
AUM32-21-02	1.94	43,890	A1	
AUM32-22-02	3.59	71,148	A1	
AUM32-23-02	4.75	45,470	A1	
AUM32-123-02	5.43	45,470	A1	
AUM32-24-02	1.53	36,444	A1	
AUM32-25-02	3.00	46,329	A1	
Transfer Area <sup>f</sup>				
AUM32-26-02	1.69	30,994	B2	
AUM32-26-12	0.963	·		
AUM32-26-24	0.786			
AUM32-26-36	0.779			
AUM32-27-02	237	356,219	B2	
AUM32-27-12	15.7			
AUM32-27-24	0.866			
AUM32-27-36	0.767			
AUM32-28-02	300	381,942	В2	
AUM32-28-12	48.3	,		
AUM32-28-24	0.759			

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 10-02-09-11-10-0004		Project No.: EE-002693-2164-01110		
	Ra-226	Surface Gamma		
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey	
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>	
AUM32-28-36	0.967			
AUM32-29-02	262	313,237	B2	
AUM32-29-12	2.68			
AUM32-29-24	2.06			
AUM32-29-36	13.9			
AUM32-30-02	4.29	38,309	B2	
AUM32-30-12	0.982			
AUM32-130-12	1.03			
AUM32-30-24	1.14			
AUM32-30-36	1.03			
AUM32-31-02	20.3	60,674	B2	
AUM32-31-12	1.56			
AUM32-31-24	1.14			
AUM32-31-36	1.07			
AUM32-32-02	7.78	35,581	B2	
AUM32-32-12	0.964			
AUM32-32-24	1.19			
AUM32-32-36	0.966			
AUM32-132-36	0.909			
AUM32-33-02	4.22	60,721	B2	
AUM32-33-12	1.02			
AUM32-33-24	1.30			
AUM32-33-36	1.16			
AUM32-34-02	20.1	62,878	B2	
AUM32-134-02	18.2	62,878	B2	
AUM32-34-12	0.921			
AUM32-34-24	1.29			
AUM32-34-36	0.740			
AUM32-35-02	2.72	47,842	B2	
AUM32-35-12	0.832			
AUM32-35-24	1.10			
AUM32-135-24	1.00			
AUM32-35-36	0.991			
AUM32-36-02	39.4	56,926	B2	
AUM32-36-12	0.986			
AUM32-136-12	1.20			
AUM32-36-24	1.60			
AUM32-36-36	0.544			

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32

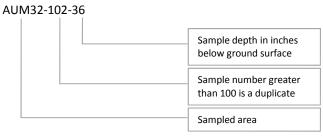
#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO

	Ra-226	Surface Gamma	1002033 2104 01110
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>
AUM32-37-02	2.60	34,570	B2
AUM32-37-12	0.846	34,370	DZ.
AUM32-37-12	0.901		
AUM32-37-36	0.777		
AUM32-38-02	13.6	67,451	B2
AUM32-138-02	12.1	67,451	B2
AUM32-38-12	1.17	07,431	DZ
AUM32-38-12	0.897		
AUM32-38-36	1.13		
AUM32-38-36 AUM32-39-02	2.84	21 100	B2
		31,108	
AUM32-40-02	0.761	28,824	B2
AUM32-41-02	0.789	29,694	B2
AUM32-42-02	3.11	31,173	B2
AUM32-43-02	0.993	27,817	B2
AUM32-44-02	23.4	89,687	B2
AUM32-44-12	1.43		
AUM32-44-24	1.04		
AUM32-144-24	0.875		
AUM32-44-36	0.815		
AUM32-45-02	0.923	27,751	A1
AUM32-46-02	1.10	26,615	A1
AUM32-47-02	0.900	29,128	A1
AUM32-48-02	2.21	29,905	A1
AUM32-148-02	2.04	29,905	A1
AUM32-49-02	108	237,696	A1
AUM32-49-12	94.8		
AUM32-49-24	6.13		

#### Notes:

a The sample ID indicates the following:



# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

Notes (continue	ad):
b	Concentrations shown in <b>bold</b> exceed the action level of 2.11 pCi/g
С	Static 1-minute measurement at sampling location
d	Paired radiation survey equipment which consisted of Ludlum
	Model 44-20 (3x3) detector and 2241 meter:
	Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844)
	and an Alpha Spectra detector (Serial No. 121611BP).
	Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852)
	and an Alpha Spectra detector (Serial No. 121611BQ).
е	Soil samples from the mine area were collected using a hand auger.
	Soil samples noted with a (G) were collected using a Geoprobe® system.
f	Soil samples from the transfer area were collected using a Geoprobe®
	system except for AUM32-49 which was collected using a hand auger.
AUM	Abandoned uranium mine
cpm	Counts per minute
pCi/g	Picocuries per gram
Ra-22	6 Radium-226

Table 4-3
Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity
Tronox AUM Section 33

#### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

Ra-226		Surface Gamma		
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey	
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>	
,		. , .		
AUM33-01-02	1.30	37,862	B2	
AUM33-01-12	1.37			
AUM33-101-12	1.38			
AUM33-01-24	1.04			
AUM33-01-36	1.05			
AUM33-02-02	20.3	116,387	B2	
AUM33-02-12	4.07			
AUM33-02-24	6.00			
AUM33-102-24	6.08			
AUM33-02-36	7.15			
AUM33-03-02	0.996	43,300	B2	
AUM33-03-12	2.14			
AUM33-03-24	1.55			
AUM33-03-36	1.14			
AUM33-103-36	1.26			
AUM33-04-02	76.1	158,830	B2	
AUM33-04-12	35.4			
AUM33-04-24	19.0			
AUM33-04-36	22.2			
AUM33-05-02	9.13	67,668	B2	
AUM33-05-12	3.93			
AUM33-05-24	4.61			
AUM33-05-36	1.32			
AUM33-06-02	1.33	37,582	B2	
AUM33-06-12	1.10			
AUM33-06-24	0.816			
AUM33-06-34	1.01			
AUM33-07-02	39.4	116,594	В2	
AUM33-07-12	5.83			
AUM33-07-24	3.36			
AUM33-07-36	2.84			
AUM33-07-36 (G)	0.847			
AUM33-07-48 (G)	1.07			
AUM33-08-02	4.78	58,287	A1	
AUM33-108-02	6.11	58,287	A1	
AUM33-09-02	6.70	81,632	A1	

### Table 4-3

## Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 33

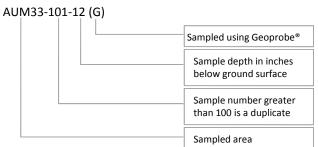
### Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0005 Project No.: EE-002693-2165-01TTO

	Ra-226	Surface Gamma	
	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>	Radiation Survey
Sample ID <sup>a</sup>	(pCi/g)	(cpm)	Equipment <sup>d</sup>
AUM33-10-02	4.31	47,868	A1
AUM33-11-02	1.37	41,483	A1
AUM33-12-02	1.45	39,720	A1
AUM33-13-02	9.70	75,707	A1
AUM33-14-02	1.65	36,513	A1
AUM33-15-02	9.85	57,764	A1
AUM33-16-02	6.59	62,778	A1
AUM33-WP-01	52.2		
AUM33-WP-02	47.7		
AUM33-WP-03	23.3		

### Notes:

a The sample ID indicates the following:



The waste pile (WP) samples were all collected from the surface (0 to 2 inches below ground surface). The last 2 digits of the sample ID of the WP samples represent the sample number.

b	Concentrations shown	n <b>bold</b> exceed	the action leve	l of 2.11 pCi/g
---	----------------------	----------------------	-----------------	-----------------

c Static 1-minute measurement at sampling location

d Paired radiation survey equipment which consisted of Ludlum

Model 44-20 (3x3) detector and 2241 meter:

Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844)

and an Alpha Spectra detector (Serial No. 121611BP).

Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852)

and an Alpha Spectra detector (Serial No. 121611BQ).

AUM	Abandoned uranium mine
cpm	Counts per minute
pCi/g	Picocuries per gram
Ra-226	Radium-226

Table 4-4

## Relationship Coefficients for Ra-226 concentrations and Static Gamma Radiation Activity in Surface Soil Tronox AUM Sections 32 and 33

## Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

		Linear
B	Correlation Coefficient	Regression Coefficient
Data Set	Coefficient	Coefficient
All data	0.77	0.60
All data less than 60 kcpm	0.78	0.61
Data from Equipment A1	0.92	0.84
Data from Equipment B2	0.75	0.56
Data from Fauinment B2 from Locations		
Data from Equipment B2 from Locations		
with No Subsurface Samples	0.86	0.73
Mine area	0.54	0.30
Mine area, less than 60 kcpm	0.89	0.79

### Notes:

Equipment A1 consisted of a Ludlum 2241-3 meter (Serial No. 256844) and an Alpha Spectra detector (Serial No. 121611BP).

Equipment B2 consisted of a Ludlum 2241-3 meter (Serial No. 256852) and an Alpha Spectra detector (Serial No. 121611BQ).

kcpm Kilocounts per minute

TDD No.: TO-02-09-11-10-0004

Project No.: EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

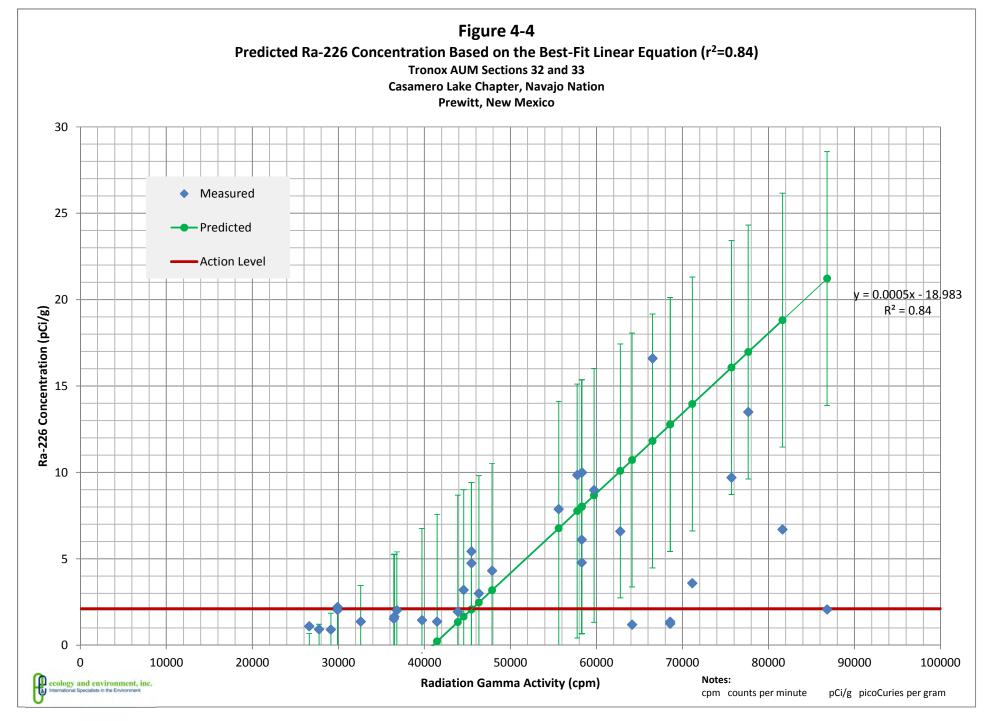
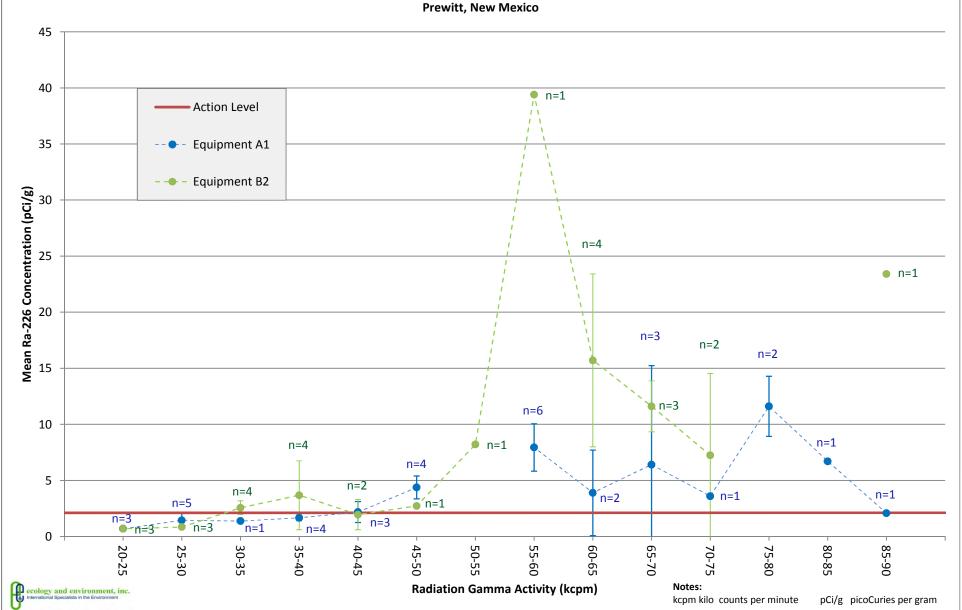


Figure 4-5
Mean Ra-226 Concentrations
Tronox AUM Sections 32 and 33
Casamero Lake Chapter, Navajo Nation



### Table 4-5

## Summary of Gamma Radiation Dose Rate Data for CL-001

## Tronox AUM Sections 32 and 33 Casamero Lake Chapter, Navajo Nation

### Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

					Background Dose Rate by			
PIC				Monitor	Date &		Background	
Instrument	Monitoring	Sub		Measurement	Instrument	Total Dose	dose	
ID	Location	Location	Date	(µR/hr)	(µR/hr)	mrem/yr1	mrem/yr <sup>1</sup>	Difference
828176	CL-001A	LR1	6/14/2012	13.61	14.46	119.3	126.8	-7.5
828176	CL-001A	LR2	6/14/2012	13.35	14.46	117.0	126.8	-9.7
828176	CL-001A	BR1	6/14/2012	13.55	14.46	118.8	126.8	-8.0
828176	CL-001B	SR	6/14/2012	13.33	14.46	116.9	126.8	-9.9
828176	CL-001B	KIT	6/14/2012	12.92	14.46	113.3	126.8	-13.5
828176	CL-001B	LR	6/14/2012	13.41	14.46	117.6	126.8	-9.2
828176	CL-001B	BR1	6/14/2012	13.19	14.46	115.6	126.8	-11.1
828176	CL-001B	BATH	6/14/2012	13.42	14.46	117.6	126.8	-9.1
828176	CL-001B	BR2	6/14/2012	13.23	14.46	116.0	126.8	-10.8
828176	CL-001C	SR	6/14/2012	13.68	14.46	119.9	126.8	-6.8

### Notes:

Assumed daily duration of exposure to hazard Assumed lifetime duration of exposure to hazard Assumed fatal cancer risk per lifetime unit dose

Assumed excess fatal cancer risk per CERCLA annual dose

24 hours/day

30 years/lifetime

7% per Sievert

7% per 100 rem

3.E-04 per 15 mrem/yr

1 Assumes 1:1 conversion when converting Roentgen to rem

BATH Bathroom
BR Bedroom
KIT Kitchen
LR Living room
SR Storage Room

μR/hr microRoentgen Per Hour

mrem/yr milliRoentgen Equivalent Man units per year

### Table 4-6

### **Summary of Gamma Radiation Dose Rate Data for CL-002**

## Tronox AUM Sections 32 and 33 Casamero Lake Chapter, Navajo Nation

## Prewitt, New Mexico

TDD No. TO-02-09-11-10-0004 Project No. EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

					Background Dose Rate by		Dookaround	
PIC				Monitor	Date &	T	Background	
Instrument	Monitoring	Sub		Measurement	Instrument	Total Dose	dose	
ID	Location	Location	Date	(µR/hr)	(µR/hr)	mrem/yr <sup>1</sup>	mrem/yr <sup>1</sup>	Difference
828176	CL-002A	LR1	6/14/2012	15.24	14.46	133.6	126.8	6.8
828176	CL-002A	LR2	6/14/2012	15.37	14.46	134.7	126.8	8.0
828176	CL-002B	LR	6/14/2012	13.40	14.46	117.5	126.8	-9.3

Notes:

Assumed daily duration of exposure to hazard Assumed lifetime duration of exposure to hazard Assumed fatal cancer risk per lifetime unit dose

=

Assumed excess fatal cancer risk per CERCLA annual dose

24 hours/day

30 years/lifetime

7% per Sievert

7% per 100 rem

3.E-04 per 15 mrem/yr

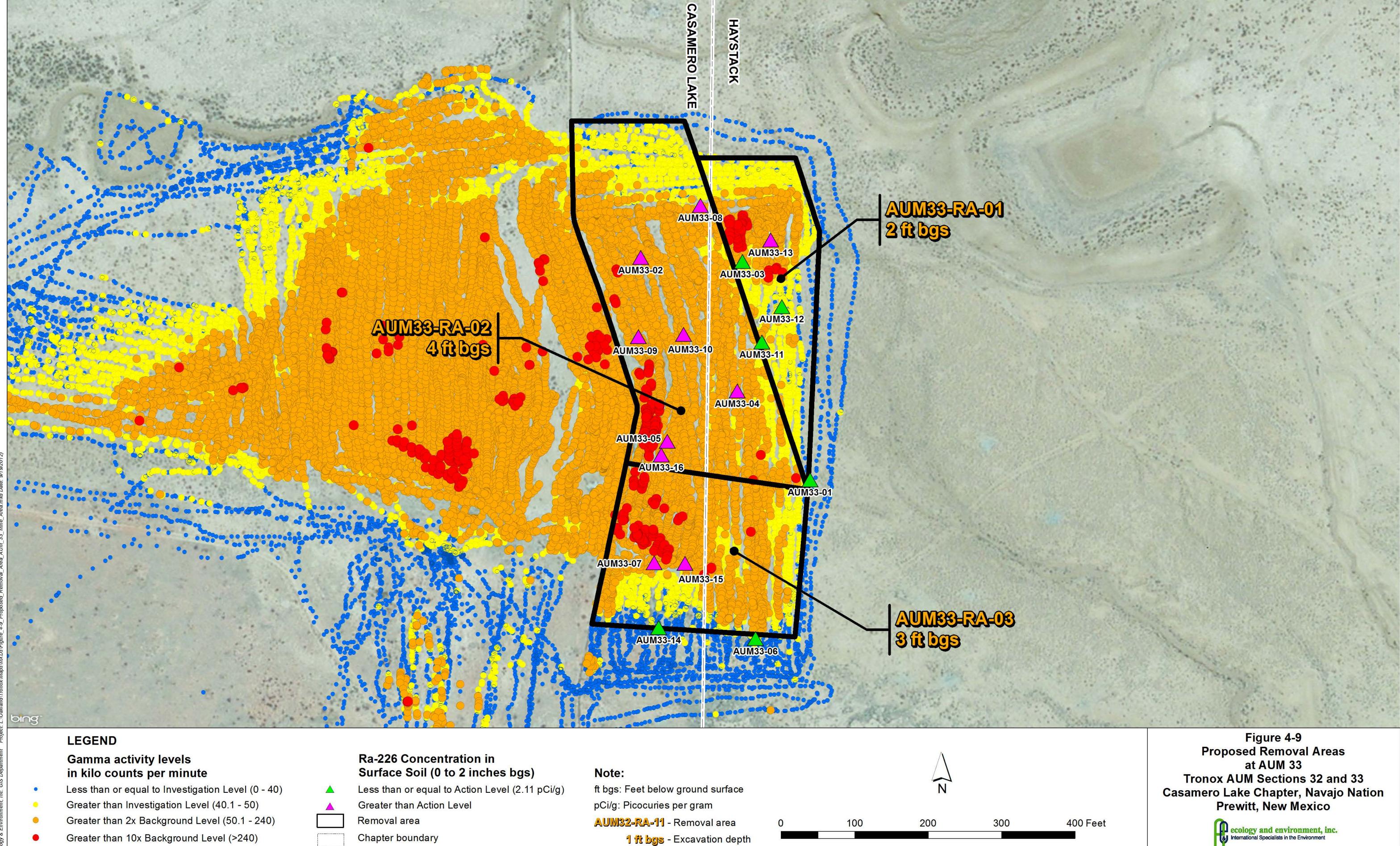
1 Assumes 1:1 conversion when converting Roentgen to rem

BATH Bathroom
BR Bedroom
KIT Kitchen
LR Living room
SR Storage Room

μR/hr microRoentgen Per Hour

mrem/yr milliRoentgen Equivalent Man units per year

Project # EE-002693-2165-01TTO
TDD# TO-02-09-11-10-0005
Source: Aerial Photography - B



### Table 4-7

## Proposed Removal Volumes Tronox AUM Sections 32 and 33 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: TO-02-09-11-10-0004 Project No.: EE-002693-2164-01TTO TO-02-09-11-10-0005 EE-002693-2165-01TTO

10-02-03-11-10-0003					
		Excavation			
	Depth	Area	Volume		
Removal Area	(feet bgs)	(ft <sup>2</sup> )	(yd³)		
AUM32-RA-01	3	23,222	2,580		
AUM32-RA-02	2	105,402	7,808		
AUM32-RA-03	1	60,850	2,254		
AUM32-RA-04	3	88,704	9,856		
AUM32-RA-05	4	30,454	4,512		
AUM 32 Mine Area	•	308,632	27,009		
AUM32-RA-06	4	23,762	3,520		
AUM32-RA-07	2	15,308	1,134		
AUM32-RA-08	1	156,756	5,806		
AUM32-RA-09	1	69,940	2,590		
AUM32-RA-10	1	2,770	103		
AUM32-RA-11	1	3,915	145		
AUM32-RA-12	3	27,822	3,091		
AUM32-RA-13	2	21,099	1,563		
AUM32-RA-14	2	1,220	90		
AUM 32 Transfer Area	-	322,592	18,043		
AUM33-RA-01	2	29,890	2,214		
AUM33-RA-02	4	76,253	11,297		
AUM33-RA-03	3	45,409	5,045		
AUM 33		151,552	18,556		
TOTAL		782,777	63,608		

### Notes:

bgs Below ground surface

ft<sup>2</sup> Square feet yd<sup>3</sup> Cubic yards

## 5 Conclusion

The removal assessment for AUM Sections 32 and 33 consisted of surface gamma radiation survey, sampling for Ra-226 analysis, and home site assessment. Surface gamma radiation activity at AUM Sections 32 and 33 was detected above background levels. Ra-226 concentrations were detected above the action level in surface soil and down to 3 feet bgs. Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. The results of the gamma radiation survey and Ra-226 analysis were used to determine the relationship between gamma radiation activity and Ra-226 concentrations and proposed removal areas. The static gamma radiation activity correlates with Ra-226 concentrations in surface soil. However, gamma radiation activity measurements cannot predict Ra-226 concentrations based on a linear relationship. Fourteen removal areas were proposed at AUM 32 and three removal areas were proposed at AUM 33. The total proposed removal volume is 63,608 cubic yards. For the home sites, the difference between the background and measured dose rate in the structures was below 15 mrem/yr which was based on an excess cancer risk of 3 x 10<sup>-4</sup>. The gamma radiation activity results inside the structures and from surface soil outside the structures within the property were below background levels. Based on the results of the removal assessment, further action is necessary at AUM Sections 32 and 33 and no further action is warranted at the home sites.

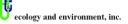
The following factors listed in the National Oil and Hazardous Substances Pollution Contingency Plan §300.415(b)(2) are present at AUM Sections 32 and 33 and may be used by USEPA in determining the appropriateness of a removal action.

(i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;

Ra-226 concentrations detected in soil to depths of 3 feet bgs at AUM Sections 32 and 33 were above background levels and PRG. The PRG is based on Ra-226 and its radioactive decay chain products (Ra-226+D) in residential soil and an estimated excess cancer risk of 1 in 10,000 (10<sup>-4</sup>) (USEPA 2010). The PRG considers human exposure pathways which include incidental ingestion of soil, inhalation of particulates emitted from soil, external exposure to ionizing radiation, and consumption of fruits and vegetables. This standardized PRG is based on default exposure parameters and incorporate exposure factors that present reasonable maximum exposure selected to be protective of human health for most site conditions.

Residents live 0.5 mile from AUM Sections 32 and 33. Vegetation and animals were observed at the AUMs. AUM 32 has no fence and signage. AUM 33 has an existing unsecured fence and no signage.

- (iv) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate;
  - Ra-226 concentrations were detected in surface soil (0 to 2 inches bgs) at AUM Sections 32 and 33 above the action level of 2.11 pCi/g, which was based on background level and PRG. Ra-226 concentrations were detected up to 300 pCi/g in surface soil which mostly had sparse vegetation.
- (v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released;



### 5. Conclusion

Thunderstorms, events of high winds, and evidence of flooding were observed at AUM Sections 32 and 33.

(viii) Other situations or factors that may pose threats to public health or welfare of the United States or the environment

AUM 32 contains an unsecured open shaft. AUM 33 contains an unsecured vent and several waste piles.

## 6 References

- Bureau of Indian Affairs, Department of Energy, Nuclear Regulatory Commission, United States Environmental Protection Agency (USEPA), and Indian Health Service. 2008. *Health and Environmental Impacts of Uranium Contamination in the Navajo Nation Five-Year Plan.* June 9.
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- Weston Solutions Inc. (Weston). 2009. Navajo Nation Abandoned Uranium Mine Site Screen Report Section 32 AUM Site, Navajo AUM Eastern Region, May.

# Removal Action Report Tronox AUM Section 32 Eastern Agency Prewitt, McKinley County, New Mexico

AUM Section 32 TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

February 2014

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY Region IX

Prepared by:

**ECOLOGY AND ENVIRONMENT, INC.** 

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## ist of Abbreviations and Acronyms

AUM Abandoned Uranium Mine

below ground surface bgs

cpm counts per minute

**FOSC** 

E & E Ecology and Environment, Inc.'s

**EML Environmental Measurements Laboratory** Emergency and Rapid Response Services **ERRS** 

**ERT Environmental Response Team** Federal On-Scene Coordinator

**GIS** Geographical Information System

Global Positioning System **GPS** 

HASL Health and Safety Laboratory high volume air sampler hi-vol **HSP** Health and Safety Plan

NAAQS National Ambient Air Quality Standards

picocurie per gram pCi/g

PRG Preliminary Remediation Goal quality assurance/quality control QA/QC

Radium-226 Ra-226

coefficient of determination

**SAP** Sampling and Analysis Plan

sf square feet

**START** Superfund Technical Assessment and Response Team

**USEPA** United States Environmental Protection Agency

Weston Solutions, Inc. Weston

## 1 Introduction

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E) Superfund Technical Assessment and Response Team (START) to support the removal action at Tronox Abandoned Uranium Mine (AUM) Section 32 located in Prewitt, McKinley County, New Mexico, in the Casamero Lake and Haystack Chapters of the Navajo Nation. AUM 32 is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (Bureau of Indian Affairs *et al.* 2008). START documented the excavated areas and conducted gamma radiation surveys and soil sampling to confirm that gamma radiation activity and Radium-226 (Ra-226) concentrations in soil remaining in place at the removal areas were below the cleanup level. This report documents the excavated areas and the results of the gamma radiation survey and soil sampling during the removal action.

## 2 Site Background

### 2.1 Site Location

AUM 32 is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Figure 1, Appendix A). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation. The Chapter House is approximately 1.4 miles northwest of AUM 32. AUM 32 consists of a former mine area (Latitude: 35°29'26.7576"N, Longitude: 108°1'2.7798"W) and transfer area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W). The mine area is bordered to the east by AUM 33, which is privately owned. The transfer area is located approximately 0.3 mile southwest of the mine area. AUM 32 is located in a range land.

## 2.2 Site Description

The AUM 32 mine area is approximately 365,005 square feet (sf) and contains an unsecured deep shaft located in the southeastern portion and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The mine area is relatively flat with sparse vegetation. Available geographical information shows an ephemeral stream or river located north and south of the mine area that converges approximately 0.25 mile west of the mine area (Figure 2, Appendix A). A 10-foot deep ditch was observed to run from east to west and bounds the mine area to the north. The ditch connects to a pond located northwest of the mine area. Approximately 309,000 sf of the AUM 32 mine area was documented to have elevated gamma radiation activity and Ra-226 concentrations in soil.

The AUM 32 transfer area is approximately 267,432 sf and contains a concrete pad and a sealed vent (E & E 2012). The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flow in a northwest direction was observed. Approximately 323,000 sf of the area around and within the AUM 32 transfer area was documented to have elevated gamma radiation activity and Ra-226 concentrations in soil.

Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during field activities documented bedrock at 3 feet below ground surface (bgs). No residences and public structures were found within 0.25 miles of AUM 32. The nearest resident lives approximately 0.5 mile to the west. Materials obtained from the mine (tarps and lumber) were reportedly used as building materials by the residents (Weston 2009). Domestic pets such as dogs, terrestrial wildlife, and horses were observed during site activities.

## 2.3 Site History

According to USEPA, portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore for national defense and energy purposes on Navajo tribal lands led to a legacy of AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

AUM 32 contained a historical mine which was reportedly owned by Cobb Nuclear Company and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations was available. No visible signs of reclamation were reported.



In June 2012, USEPA and Navajo Nation Environmental Protection Agency interviewed a local resident who pointed out the location of a former transfer area southwest of the AUM 32 mine area. A concrete pad where a crane was reportedly mounted was located in the presumed former transfer area. The resident had relatives who formerly worked for Cobb Nuclear Company and reported that rail cars transported material south and southeast of the mine. The reported structures were not evident in historical aerial photographs available after the July 2012 USEPA-led assessment activities (E & E 2012) discussed in the following section.

## 2.4 Previous Investigation

A site screening was conducted at AUM 32 which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the initial boundary of the mine area and along two diagonal intersecting transects from the mine area's four corners. Gamma radiation activity measurements ranged from 10,689 to 180,367 counts per minute (cpm) at AUM 32. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 to 17,128 cpm. The building materials in the nearest residence had gamma radiation measurements of approximately 12,000 cpm.

In June and July 2012, a removal assessment was conducted by USEPA and START at AUM 32 (E & E 2012). The removal assessment consisted of surface gamma radiation survey, sampling of soil and waste piles for Ra-226 analysis, and home site assessment. Gamma radiation activity in surface soils at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 cpm at the AUM 32 mine area and 16,880 to above 1,000,000 cpm at the AUM 32 transfer area. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were documented above the action level of 2.11 picocuries per gram (pCi/g) in surface soil and down to 3 feet bgs. Ra-226 was detected up to 300 pCi/g. The action level was based on the highest background level recorded and the preliminary remediation goal (PRG), which is based on an estimated excess cancer risk of 1 in 10,000 (10<sup>-4</sup>), for Ra-226 and its radioactive decay chain products in residential soil (USEPA 2010). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. The results of the removal assessment defined areas of soil to be removed at AUM 32 to protect human health. Fourteen removal areas were proposed at AUM 32 (Figures 3 through 5, Appendix A). An estimated 27,009 cubic yards of soil was identified for removal at the mine area and 18,043 cubic yards of soil was calculated for removal at the transfer area. Based on the results of the removal assessment, USEPA determined a removal action was necessary at AUM 32.

A cultural resources inventory survey was conducted on September 19, 2012 by an Emergency and Rapid Response Services (ERRS) subcontractor. According to the survey, no cultural resources or sacred places were located in the area of the site (CSWTA, Inc. 2012). Archaeological clearances were recommended before removal of the mine.

## 3 START Field Activities

START mobilized to AUM 32 on October 9, 2012 and demobilized on November 15, 2012. USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis, USEPA Environmental Response Team (ERT), and ERRS were also on site. The START field activities for the removal action consisted of the following:

- 1. Documentation of excavation activities at AUM 32.
- 2. Surface gamma radiation surveys of soil remaining in place in the excavated areas.
- 3. Sampling of surface soil remaining in place at the excavated areas for Ra-226 analysis.

Prior to mobilization, the START prepared the *Sampling and Analysis Plan* (SAP), *Tronox AUM Sections 32 and 33 Removal Action, Prewitt, McKinely County, New Mexico*, dated October 2012, and approved by the U.S. EPA FOSC Randy Nattis. E & E START followed all predetermined standard operating procedures (SOPs) for sample collection, sample handling, and site documentation as outlined in the SAP during the removal activities of this project, unless otherwise specified below in Section 3.1.The data objectives of the SAP were to:

- 1. Determine whether gamma radiation activity in soil remaining in place within the removal area required additional excavation removal or confirmation sampling for Ra-226 analysis.
- 2. Determine whether concentrations of Ra-226 in soil remaining in place within the removal area required removal or no further action.

Appendix C contains photographs of the field activities.

## 3.1 Site-Specific SAP Deviations

The following deviations from the SAP (Appendix B) resulted from changes made at the direction of FOSC Nattis during the field assessment in response to field observations and conditions:

- AUM32-RA-15, -16, and -17 were added to the removal action due to elevated gamma radiation activity found in these areas.
- Soils were excavated to 50,000 cpm in removal areas AUM32-RA-05, -08, -15, and -16 and not the cleanup level of 40,000 cpm addressed in the SAP.
- After initial excavations, removal areas were only excavated to a maximum depth of 4-ft bgs regardless of gamma radiation activity readings.
- Removal areas AUM32-RA-14 and -17 were not addressed as planned during this removal activity; they will be addressed during a future removal action for the Section 33 AUM site.



### 3.2 Documentation of Excavation Activities

The proposed removal areas were marked by START on site using a global positioning system (GPS) unit and stakes color-coded according to the planned excavation depth. The boundaries of areas excavated by ERRS were documented by START using a GPS unit. Data was mapped using geographical information system (GIS) software. GPS data for site features such as roads, telephone poles, work zones, and stockpile area were also collected.

Thirteen of fourteen proposed removal areas (AUM32-RA-01 through -13) were excavated during the removal action (Figures 6-7, Appendix A). AUM32-RA-14, which was originally proposed for removal, will be addressed as part of a removal action at AUM 33. Three additional removal areas, AUM32-RA-15, 16, 17 (Figure 6, Appendix A), were identified during the pre-excavation gamma radiation survey. AUM32-RA-15 and -16 were excavated during the removal action. ERRS did not excavate AUM32-RA-17 due to it being part of a drainage ditch that flows from the Section 33 property that will be remediated at a future time. A total of 607,445 sf and 34,686 cubic yards were excavated from AUM 32. The final excavation boundaries are shown in Figures 6 and 7 (Appendix A). The final excavation volumes are presented in Table 1 (Appendix D). The excavated material was placed in a stockpile located in the AUM 32 mine area.

During excavation in the removal areas, three mine shafts were over excavated to the extent possible with the excavator and backfilled. On October 19, 2013, the open mine shaft located in AUM32-RA-04 was over excavated exposing underground structures such as rail lines and steel cables. On October 23, 2013 a second mine shaft was discovered near the first mine shaft. Excavation at the mine shafts in AUM32-RA-04 and -05 was discontinued at 12 feet because soil was caving in and backfilling the holes. On November 8, 2013, a third mine shaft was discovered in AUM32-RA-08. The hole was 5 by 5 feet in area and 10 feet deep and was covered by a 6- by 6-foot, 8-inch thick concrete slab. The hole in AUM32-RA-08 was over excavated to a 12- by 12-foot area and 4 feet bgs depth where a rock with elevated gamma activity was detected. Gray material with elevated gamma activity was found adjacent to the mine shaft and was also excavated. At all three mineshaft locations the gamma activity readings were recorded above the action level of 40,000 cpm and below 50,000 cpm. OSC Nattis directed that the soils in the vicinity of the mineshafts be excavated to a gamma radiation activity level of 50,000 cpm as they would also be backfilled with cleaner, lower gamma activity soils. The excavated area was backfilled to 1 foot bgs with soil from an adjacent area. Photographs of the mine shafts are included in Appendix C.

Final excavated areas were graded and contoured to blend with the overall topography and drainage course of the area according to the specifications in the "Site Restoration Preliminary Design for Sections 32 & 33 Abandoned Uranium Mines, Casamero Lake Chapter, New Mexico" prepared by the Scientific, Engineering, Response and Analytical Services contractor for ERT (Lockheed Martin 2012).

Soil removed from the excavated areas was placed in an interim stockpile located in the AUM 32 mine area (Figure 8, Appendix A). The stockpile area occupies 121,840 sf and has a height of 30 feet above the surrounding ground surface. The stockpile was constructed by ERRS according to the site restoration specifications (Lockheed Martin 2012). After excavated materials from all removal areas were placed on the stockpile, the stockpile was compacted with a smooth roller and then a soil stabilizer and dust control agent called Gorilla-Snot® was applied on the compacted stockpile by spraying with a water truck. Gorilla-Snot®, manufactured by



Soilworks®, LLC, is an eco-safe, biodegradable, liquid copolymer used to stabilize and solidify soil for erosion control and dust suppression. A surface runoff drainage system was then constructed around the base of the stockpile and away from the stockpile to the west. Finally, a fence with signage was installed around the perimeter of the stockpile to prevent access and help maintain the integrity of the stockpile area until USEPA determines a final action.

## 3.3 Surface Gamma Radiation Surveys

Surface gamma radiation surveys were conducted using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter. Operational checks were conducted on the paired meter and detector before the field activities using a Spectrum Techniques check source with 2 microcuries of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument was set using a Fluke voltage meter. An operational and background check was also conducted before each survey day.

Surface gamma radiation surveys were conducted in the background area and excavation areas at AUM 32. The radiation survey equipment was mounted 6 inches from the ground surface to measure gamma radiation activity in surface soil. Real-time *in situ* surface soil surveys consisted of traversing 3- to 6-foot wide transects covering 100 percent of the survey area at a pace of 3 feet per second. The transect width was based on the field of view of the detector, which was 3 to 6 feet in diameter.

The VIPER system and GIS were used for geospatial information collection and analysis before and after excavation. VIPER is a wireless network-based communications system designed to enable real time transmission of data from field sensors to a local computer, remote computer, or enterprise server also providing data management, analysis, and visualization. The radiation survey meters were linked to the VIPER system which stored the data throughout the collection period. Survey data was downloaded from the VIPER system at the end of each day and processed using GIS.

FOSC Nattis directed START to confirm that the removal area boundaries were in fact the boundaries of lower gamma radiation activity below the 40,000 cpm action level by conducting a pre-excavation surface gamma radiation survey. As a result of the additional survey, AUM32-RA-15 and AUM32-RA-16 located west of AUM32-RA-01; and AUM32-RA-17 located north of AUM32-RA-03 were added for removal. The results of the pre-excavation surface gamma radiation survey at AUM 32 are shown in Figure 10 and 11 (Appendix A). Gamma radiation activity ranged from 1,620 to 298,110 cpm.

Interim surface gamma radiation surveys guided further excavation. Interim surveys during excavation were conducted by walking 5 feet from the perimeter of the excavation while holding the radiation survey equipment 6 inches from the floor of the excavation. As directed by FOSC Nattis, areas with levels greater than 50,000 cpm were further excavated at 1-foot lifts and stepouts. Elevated gamma activity was detected at the mine shafts located in the removal areas. Surface gamma radiation levels at the two mine shafts located in AUM32-RA-04 were 500,000 and greater than 999,000 cpm during excavation. Surface gamma radiation levels at the mine shaft located in AUM32-RA-08 were greater than 120,000 cpm. A rock located at a depth of 4 feet bgs in the hole had a gamma activity measurement as high as 100,000 cpm. Gray material found adjacent to the mine shaft had gamma activity levels of greater than 600,000 cpm.



After completion of all planned excavation, a final surface gamma radiation survey covering 100 percent of the excavation footprint was conducted from November 12 through 15, 2012. The results of the final surface gamma radiation survey at AUM 32 are shown in Figures 8 and 9 (Appendix A). Gamma radiation activity ranged from 470 to 134,470 cpm. No further excavation was conducted at areas with gamma radiation activity below 50,000 cpm and at depths exceeding 4 feet bgs as directed by FOSC Nattis.

Areas with elevated gamma radiation activity were left in place at AUM32-15, 16, and -17. AUM32-17 was not excavated at all as it was located along a drainage ditch that runs through elevated mine waste piles to the east in Section 33, which is private land. FOSC Nattis decided to leave the drainage in its current state as it will be addressed when remedial activities are conducted in the neighboring property to the east at Section 33. AUM-15 and -16 are part of an old roadway that was added to the removal areas and was excavated with a front end loader to 0.5-ft bgs. As directed by FOSC Nattis, these areas were only excavated to gamma activity readings of 50,000 cpm and not the action level of 40,000 cpm. An area of 8,676 sf of soil with gamma radiation activity greater than 50,000 cpm and a maximum of 134,470 cpm in was left in place at AUM32-08 in a drainage ditch area that ERRS and FOSC Nattis did not want to excavate further. In AUM32-15, an area of 1,656 sf with a maximum gamma radiation activity of 61,801 cpm was left in place as directed by FOSC Nattis.

### 3.4 Soil Sampling for Ra-226 Analysis

Soil samples were collected on November 15 and 16, 2012, after all removal was completed. Confirmation soil samples were collected from three locations within the excavation footprint of each removal area determined to be below the cleanup level based on gamma radiation activity measurements. Confirmation soil sample locations in each removal area were determined using Visual Sampling Plan software version 6.2 (Pacific Northwest National Laboratory 2013) and located in the field using a GPS unit pre-loaded with the GIS-assigned coordinates. The sampling locations are shown in Figures 8 and 9 (Appendix A). Discrete surface soil samples were collected from 0 to 2 inches bgs using a sterile plastic scoop and placed in a 4-ounce plastic jar. Non-soil material including rocks larger than about ½-inch median diameter were removed from the soil sample. Surface static 1-minute gamma radiation activity was also measured at soil sampling locations to determine the relationship between surface gamma radiation activity level and Ra-226 concentration in soil left in place. Sample information was recorded in the field logbook. A total of 45 discreet surface soil samples were collected.

Duplicate samples were collected from 10 percent of the total soil samples to assess sample variability. A total of five duplicate samples were collected.

Sample jars were stored in a cooler according to the laboratory requirements and shipped at the end of field activities to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina. Chain-of-custody forms were completed and sent with the sample shipment. The samples were analyzed for Ra-226 by Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (Department of Energy 1990).

## 3.5 Health and Safety Monitoring

Radiation contamination monitoring and air sampling were conducted during the removal action according to START's Health and Safety Plan (HSP) (Appendix B). Personnel and equipment



### 3. START Field Activities

were scanned for radiation before leaving the site. Radiation levels detected on personnel during the removal were below the HSP action level. Equipment was decontaminated until detected radiation was below the HSP action level.

Dust monitoring data was collected with a Thermo Scientific DataRAM 4<sup>TM</sup> particulate monitor. The dust data collected over 24 work days were compared to National Ambient Air Quality Standards (NAAQS) to ensure adequate dust control measures were in place during removal activities. The DataRAM 4 was situated near the command post at a location between the work zone to the east and the closest residence to the west. Dust concentrations exceeded the NAAQS on several occasions but the exceedences were all on days with high wind and dust storms at the site and therefore not attributed to removal activities on site.

Air samples were also collected for 24 days when removal activity work included excavation and backfilling. Samples were collected using F&J Specialty Products, Inc high volume (hi-vol) air samplers. One hi-vol sampler was located in the work zone around dust-generating activities, another upwind and near the command post to the west or set up at the closest residence further to the west. After a day of sampling, the 4-inch filters were removed from the sampler and a 1 minute count on the filter was run in a Ludlum 3030 alpha counter. The air samples' alpha activity was compared to indicator radioisotopes selected based on the most conservative derived air concentration published by the U.S. Nuclear Regulatory Commission. Dust concentration and radioisotope activity detected throughout the removal action were below the HSP action levels.

## 4 Results

Once data were generated by GEL Laboratories, a data review was completed, and the laboratory data were validated using the *Region 9 Draft Superfund Data Evaluation/Validation Guidance* (U.S. EPA, 2001). A START chemist then conducted Tier 2 data validation for all laboratory-generated data in accordance with the EPA guidance *Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures* (EPA/540/G-90/004 OSWER Directive 9360.4-01) April 1990 (U.S. EPA, 1990). All analytical results were found to be acceptable to meet project objectives for use as definitive-level data without qualification. Validated analytical results are included in Appendix E.

## 4.1 Soil Sampling for Ra-226 Analysis

Each detected Ra-226 concentration was compared to the action level of 2.11 pCi/g which was based on the sum of the highest background concentration of Ra-226 and the USEPA PRG of 1.21 pCi/g (USEPA 2010).

Ra-226 concentrations detected in surface soil left in place are shown in Figures 8 and 9 (Appendix A). The sample results and co-located 1-minute gamma radiation activity measurements from AUM 32 are presented in Table 2 (Appendix D). Ra-226 concentrations in surface soil at AUM 32 ranged from 0.8 to 31.4 pCi/g. The following locations exceeded the action level of 2.11 pCi/g:

- AUM-32-RA-03-1 located on the north boundary of AUM32-RA-03 contained 28.7 pCi/g of Ra-226 at 1 foot bgs. During interim gamma activity measurements, this location was marked by START for further excavation but was not removed by ERRS.
- AUM-32-RA-03-3 located north of the stockpile contained 5.14 pCi/g of Ra-226 at 1 foot bgs. The gamma radiation activity at this location was less than 50,000 cpm, which as previously noted, was the level that FOSC Nattis directed be left in place. AUM-32-RA-03-2 located west of this elevated location was below the action level.
- AUM-32-RA-05-2 and -3 located along the fence line between AUM32 and AUM33 contained 7.73 and 3.32 pCi/g, respectively, of Ra-226 at 4 feet bgs. The gamma radiation activity at these locations were less than 50,000 cpm.
- AUM-32-RA-08-2 located in the drainage in the transfer area contained 31 pCi/g of Ra-226 at 1 foot bgs. This location was in an area left in place with elevated gamma radiation activity as discussed in Section 3.3. During interim gamma activity measurements, this area was marked by START for further excavation but was not removed by ERRS.
- AUM-32-RA-10-1 located on the southern boundary of the removal area contained 15.5 pCi/g of Ra-226 at 1 foot bgs. During interim gamma activity measurements, this location was marked by START for further excavation but was not removed by ERRS.
- AUM-32-RA-11-3 located on the southern boundary of the removal area contained 2.52 pCi/g, which was slightly above the action level of 2.11 pCi/g for Ra-226, at 1 foot bgs. The gamma radiation activity at this location was less than 50,000 cpm. The Ra-226



concentrations detected in the other two locations (AUM-32-RA-11-1 and -2) in soil left in place in this removal area were both below the action level.

- AUM-32-RA-12-2 located in the center of the removal area contained 31.4 pCi/g of Ra-226 at 3 feet bgs. The gamma radiation activity at this location was less than 50,000 cpm.
- AUM-32-RA-13-1 and -2 located in the western portion of the removal area contained 3.24 and 2.75 pCi/g, respectively, of Ra-226 at 2 feet bgs. The gamma radiation activity at these locations were less than 50,000 cpm.
- All sampling locations at AUM-32-RA-15 and -16 exceeded the action level of 2.11 pCi/g for Ra-226 at 0.5 foot bgs. The gamma radiation activity at these locations were less than 50,000 cpm, except for AUM-32-RA-15-1 where the gamma radiation activity was 61,000 cpm as discussed in Section 3.3. As directed by FOSC Nattis, removal at AUM-32-RA-15 and -16 was complete after ERRS scraped the areas to 0.5 foot bgs using a front end loader.

## 4.2 Relationship between Gamma Radiation Activity and Ra-226 Concentration

Gamma radiation activity measurement was used as a field screening tool during the removal action to estimate Ra-226 concentrations in soil left in place because results from laboratory analysis would not be available in a time-frame that allowed for real-time site decision making. According to the assessment report, locations with gamma radiation activity measurements below 40,000 cpm measured using the same equipment will likely have mean surface soil concentrations of Ra-226 below the action level of 2.11 pCi/g; however, the gamma radiation activity measurements may be affected by equipment used, subsurface radiation activity, and other factors that result in a non-linear relationship with Ra-226 concentrations in surface soil (E & E 2012). During the removal action, 22 percent of the Ra-226 concentrations in confirmation soil samples with co-located 1-minute gamma radiation activity measurements below 40,000 cpm were above the action level of 2.11 pCi/g. To determine if the confirmation data from the removal action show a similar relationship as the removal assessment data, correlation and linear regression analyses were performed.

Correlation analysis measures the strength of association between the paired quantitative variables in the form of a correlation coefficient. The value of a correlation coefficient ranges from -1 for perfect negative correlation, to zero for no correlation at all, to +1 for a perfect positive correlation. The equation for the correlation coefficient is:

$$Correl(X,Y) = \frac{\sum (x - \overline{x})(y - \overline{y})}{\sqrt{\sum (x - \overline{x})^2 \sum (y - \overline{y})^2}}$$

Where:

*x*,*y* is the paired (co-located) 1-minute gamma radiation activity measurement and Ra-226 sample result from surface soil

 $\bar{x}$  is the mean of the 1-minute gamma radiation activity measurements

 $\overline{y}$  is the mean of the Ra-226 sample results



The correlation coefficient calculated from the confirmation soil data using Excel (Microsoft 2010) was 0.78, which was similar to the removal assessment (E & E 2012).

Linear regression analysis was conducted to determine if the relationship between co-located 1-minute gamma radiation activity and Ra-226 concentration in surface soil may be predicted by the linear equation y=mx+b.

### Where:

y is the predicted Ra-226 concentration m is the slope of the line x is the measured 1-minute gamma radiation activity b is the y-intercept of the line

Linear regression analysis was conducted using Excel (Microsoft 2010) which determined the linear least squares curve that best fits the paired data and calculated the coefficient of determination  $(r^2)$ . The  $r^2$  compares estimated and actual y values, and ranges in value from 0 to 1. If  $r^2$  equals 1, there is a perfect correlation in the sample; i.e., there is no difference between the estimated y value and the actual y value. If  $r^2$  equals 0, the regression equation is not helpful in predicting a y value. The  $r^2$  calculated from the confirmation soil data was 0.60, which was lower than the  $r^2$  (0.84) calculated during the removal assessment (E & E 2012). Ra-226 concentrations and the measured co-located 1-minute gamma radiation activity did not show a linear relationship.

Gamma radiation activity measurements may be affected by various factors including soil conditions. On November 10, 2012, snow fell at the site. Snow cover and resulting soil moisture may have attenuated gamma radiation activity measured during the final survey and confirmation sampling (Offenbacher and Colbeck 1991). The relationship between gamma radiation activity and Ra-226 concentration likely varies with soil conditions. Therefore, gamma radiation activity measurements that are used to compare pre- and post-action should be performed in similar conditions.

## 5 Summary and Conclusions

The removal action at AUM 32 excavated soil from 15 removal areas. In addition, three mine shafts located at AUM32-RA-04, -05 and -08 were over excavated to the extent possible and backfilled. Final excavated areas were graded and contoured to blend with the overall topography and drainage course of the area. A total of 607,445 sf and 34,686 cubic yards were excavated at AUM 32.

Soil removed from the excavated areas was placed in an interim stockpile located in the AUM 32 mine area. After excavated materials from all planned removal areas were placed on the stockpile, a soil stabilizer and dust control agent was applied. The stockpile occupied 121,840 sf with a height of 30 feet. A surface runoff drainage system was constructed in the stockpile area. Finally, a fence with signage was installed around the perimeter to prevent access and help maintain the integrity of the stockpile area until USEPA determines a final action.

After completion of all planned excavation, a final surface gamma radiation survey was conducted covering 100 percent of the excavation footprint. Gamma radiation activity ranged from 470 to 134,470 cpm in soil left in place. No further excavation was conducted at areas with gamma radiation activity below 50,000 cpm and at depths exceeding 4 feet bgs as directed by FOSC Nattis. Areas with elevated gamma radiation activity were left in place at AUM32-08, -15, and -17.

Confirmation samples of the soils left in place were collected from 45 locations after the final gamma radiation survey. Ra-226 concentrations in 16 of the sampled locations exceeded the action level of 2.11 pCi/g. The highest Ra-226 concentration in soil left in place was 31.4 pCi/g.

Twenty two percent of the elevated Ra-226 concentrations had co-located 1-minute gamma radiation activity measurements below 40,000 cpm. The attenuated gamma radiation activity measured may be due to snow at the site before the gamma radiation activity measurements.

The removal action decreased the gamma radiation activity levels and Ra-226 concentrations in accessible soil areas at AUM 32. However, further action is necessary at AUM 32 as the stockpile was not a permanent remedy. Elevated gamma radiation activity levels and Ra-226 concentrations remain in place in some areas of AUM 32. In addition, two proposed removal areas (AUM32-RA-14 and -17) adjacent to AUM 33 were not excavated during this removal action and may be addressed during the removal action at AUM 33.

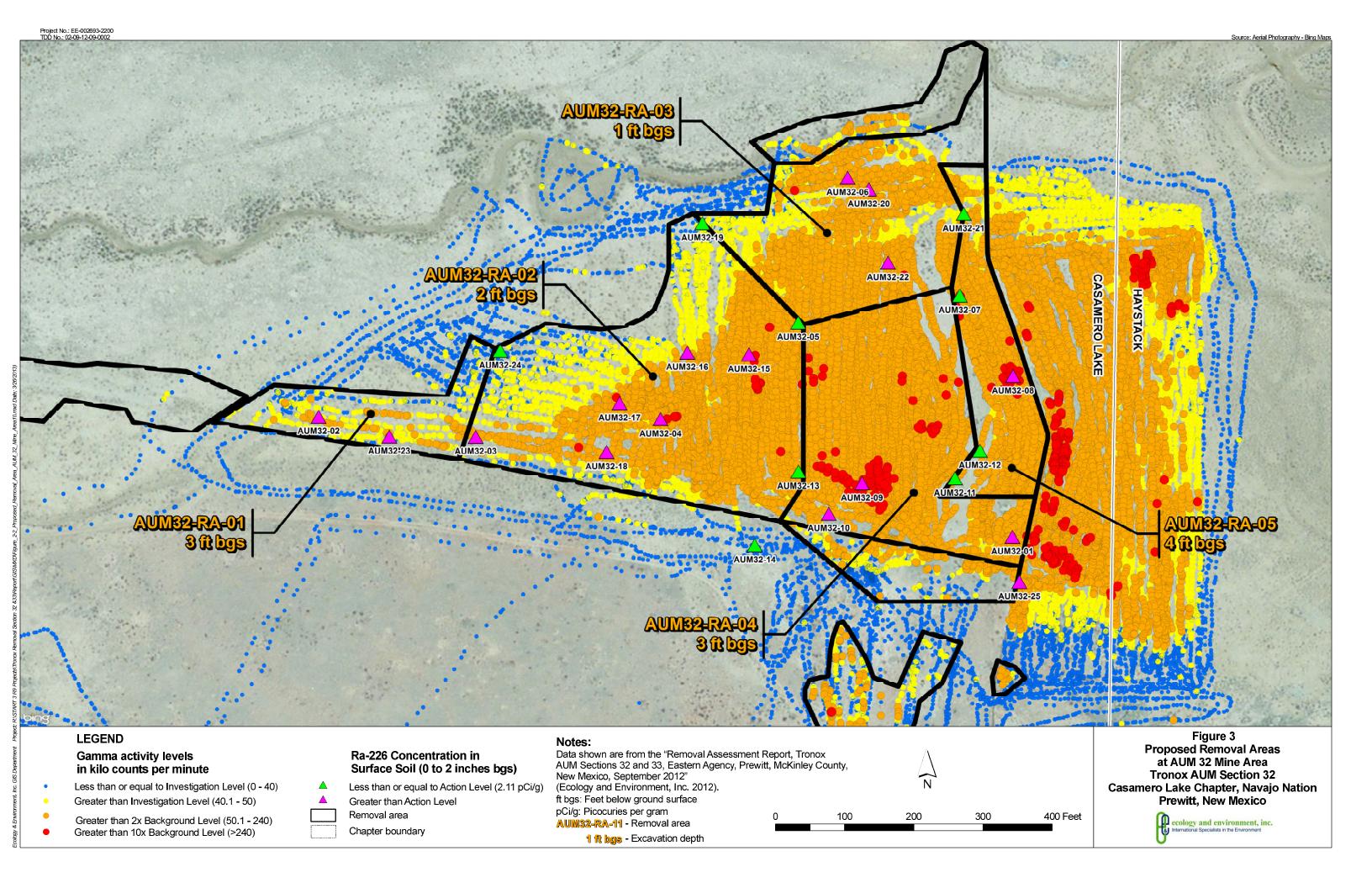
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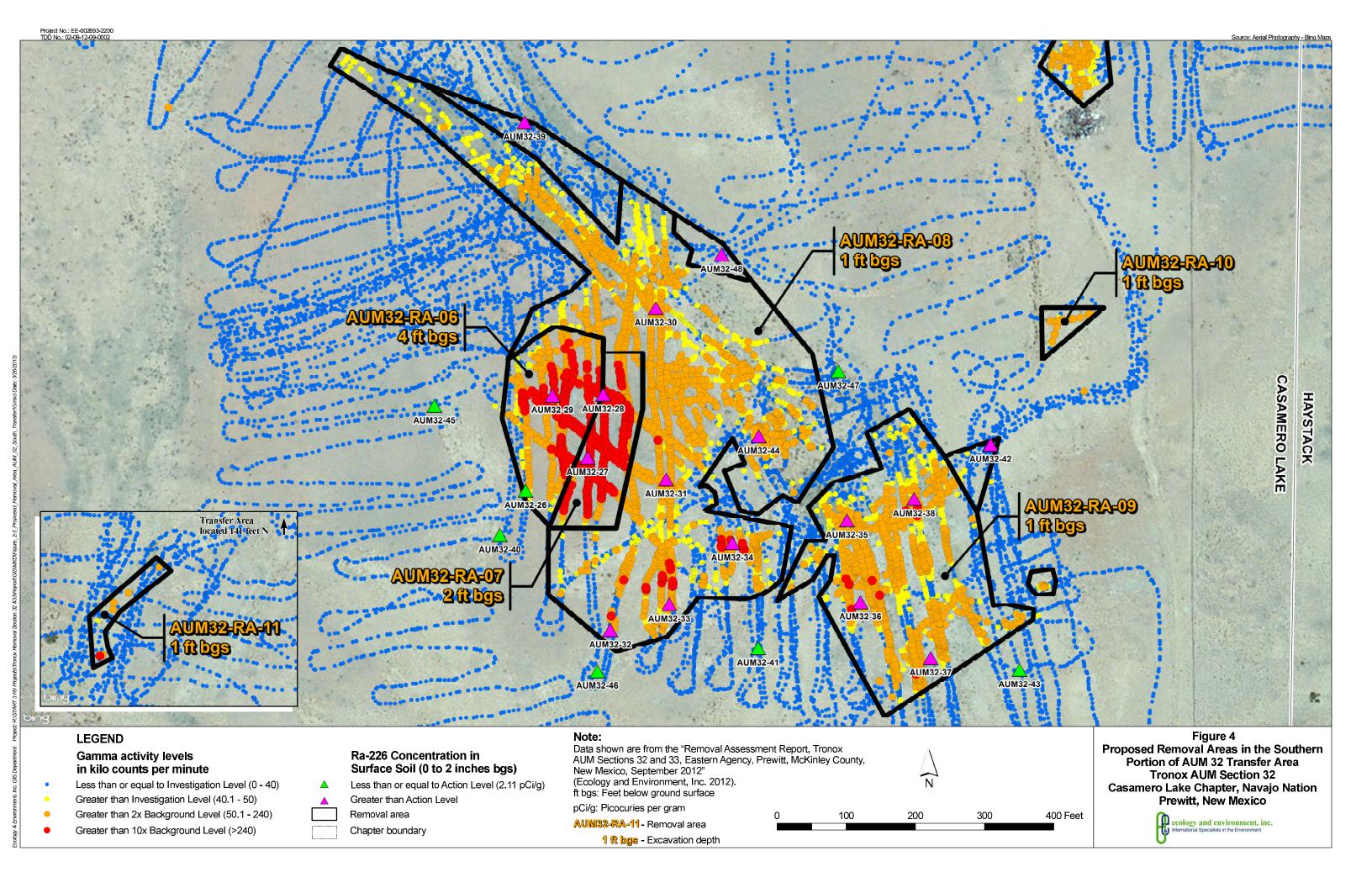
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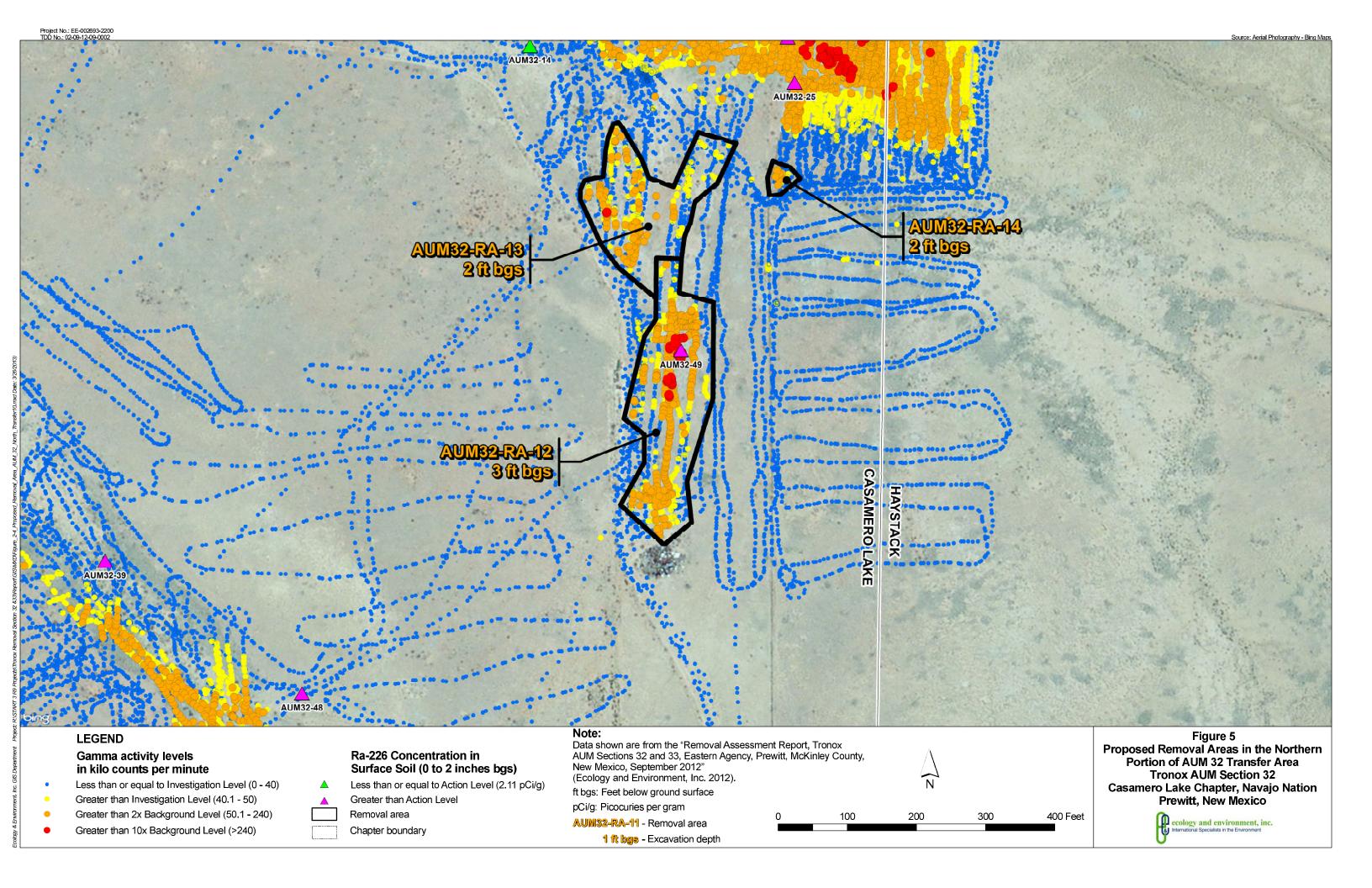


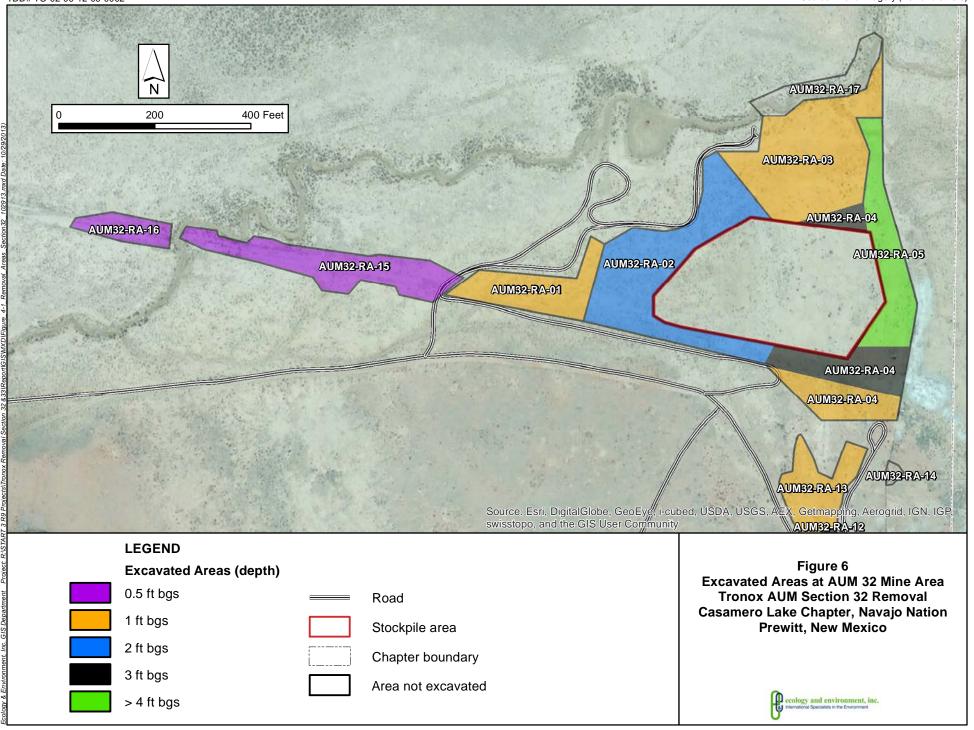
## **Appendix A: Figures**

Project No.: EE-002693-2200 TDD No.: 02-09-12-09-0002 Source: Aerial Photography - Bing Maps, County Roads - Navajo DOT Casamero Lake Chapter House **AUM Section 32** CASAMERO LAKE CHAPTER HAYSTACK CHAPTER CR 19 North Chaves Thoreau bing CR 23 Figure 1 **LEGEND Site Location Map Tronox AUM Section 32** Site area **Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico** Chapter boundary 4 Miles ecology and environment, inc.
International Specialists in the Environment







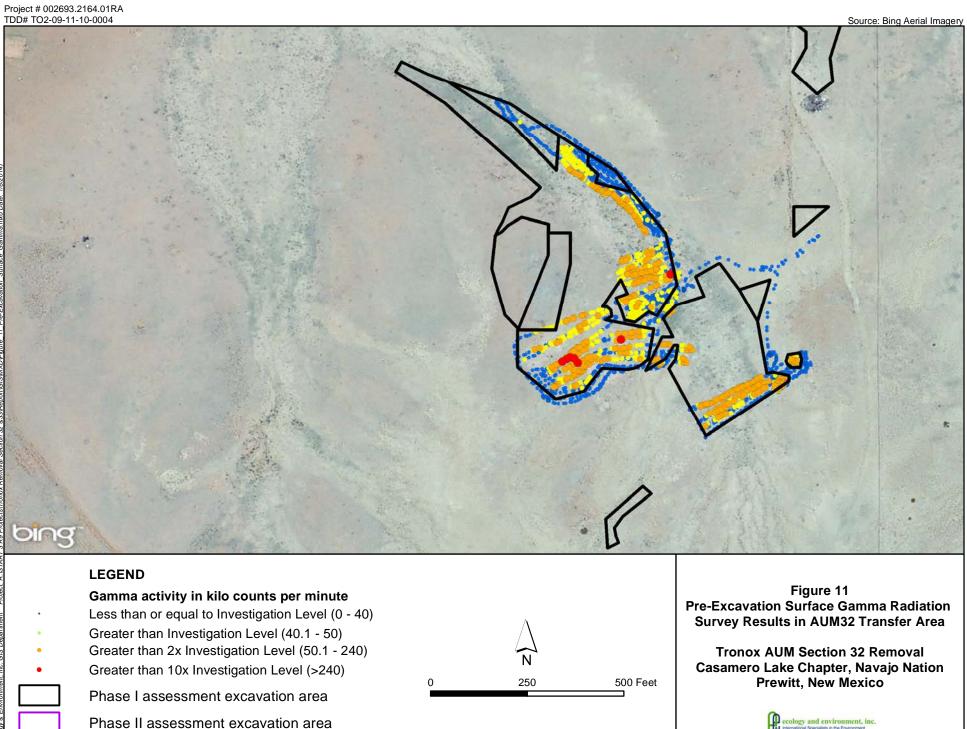


Phase I assessment excavation area

Phase II assessment excavation area

**Prewitt, New Mexico** 







Appendix B: Sampling and Analysis Plan

# Sampling and Analysis Plan Tronox AUM Sections 32 and 33 Removal Action Prewitt, McKinley County, New Mexico

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

October 2012

**Prepared for:** 

U.S. ENVIRONMENTAL PROTECTION AGENCY Region IX

Prepared by:

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#### **Superfund Technical Assessment and Response Team**

Sampling and Analysis Plan Tronox AUM Sections 32 and 33 Removal Action Prewitt, McKinley County, New Mexico

> TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

> > October 2012

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### ist of Abbreviations and Acronyms

AUM Abandoned Uranium Mine

ARARs Applicable or Relevant and Appropriate Requirements

bgs below ground surface

COPC contaminant of potential concern

cpm counts per minute

DQI Data Quality Indicator

DQO Data Quality Objective

E & E Ecology and Environment, Inc.

EML Environmental Measurements Laboratory

ERT Environmental Response Team

FOP field operating procedure

FOSC Federal On-Scene Coordinator

GPS Global Positioning System

HASL Health and Safety Laboratory

ID identification

IDW investigation-derived waste

LCS laboratory control sample

MS/MSD matrix spike/matrix spike duplicate

NA not applicable

NNEPA Navajo Nation Environmental Protection Agency

pCi/g picocurie per gram

PM Project Manager

#### **List of Abbreviations and Acronyms (cont.)**

PPE personal protective equipment

PRG Preliminary Remediation Goal

QA quality assurance

QC quality control

Ra-226 Radium 226

Ra-226+D Ra-226 and its radioactive decay chain products

RPD relative percent difference

SAP Sampling and Analysis Plan

SD standard deviation

SOP standard operating procedure

START Superfund Technical Assessment and Response Team

USEPA United States Environmental Protection Agency

VSP Visual Sampling Plan

Weston Weston Solutions, Inc.

### 1 Introduction

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support the removal action at the Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico in the Casamero Lake Chapter of the Navajo Nation (site). The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA *et al.* 2008). START will conduct gamma radiation survey and soil sampling to document that gamma radiation activity and Radium-226 (Ra-226) concentration in soil remaining in place at removal areas at the site are below the cleanup level. Under the direction of USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis, project data quality objectives (DQO) were developed and START prepared this Sampling and Analysis Plan (SAP).

This SAP describes the project and data use objectives, data collection rationale, data quality assurance goals, and requirements for sampling and analysis activities. It also defines the sampling and data collection methods that will be used for this project. This SAP is intended to accurately reflect the planned data-gathering activities for this task; however, site conditions, budget, and additional USEPA direction may warrant modifications. All significant changes will be documented in site records.

The specific field sampling and chemical analysis information in this SAP was prepared according to the following USEPA documents: *USEPA Requirements for Quality Assurance Project Plans, USEPA QA/R 5, USEPA/240/B 01/003* (USEPA 2001), *Guidance on Systematic Planning Using the Data Quality Objectives Process, USEPA QA/G 4, USEPA/240/B-06/001* (USEPA 2006), *Guidance on Choosing a Sampling Design for Environmental Data Collection, USEPA QA/G 5S, USEPA/240/R 02/005* (USEPA 2002), and *Uniform Federal Policy for Implementing Environmental Quality System, USEPA/505/F-03/001* (USEPA 2005).

#### 1.1 Project Organization

**USEPA FOSC** – The USEPA FOSC, Randy Nattis, is the primary decision-maker and will direct the project, specify tasks, and ensure that the project is proceeding on schedule and within budget. Additional duties include coordination of all preliminary and final reporting and communication with the Navajo Nation Environmental Protection Agency (NNEPA), START Project Manager (PM), USEPA Environmental Response Team (ERT), USEPA Quality Assurance (QA) Office, and community. The USEPA FOSC is also responsible for access to the site.

**START PM** – The START PM, Craig Tiballi, manages the project's data collection efforts and is responsible for implementing the SAP, coordinating project tasks and field sampling, managing field data, and completing all preliminary and final reporting.

**Principal Data Users** – Data generated during the implementation of this SAP will be utilized by the USEPA FOSC to document the removal action.

**START QA Coordinator** – The START QA Coordinator, Howard Edwards, is responsible for overseeing the development of this SAP. The START QA Coordinator will coordinate with the



USEPA's QA Office as needed. START QA Coordinator will provide QA oversight to ensure that planning and plan implementation are according to the USEPA regional quality assurance/quality control (QA/QC) protocol. START QA Coordinator will provide technical direction concerning QA/QC as needed to the USEPA FOSC and the START PM.

**Sample Analysis and Laboratory Support** – The START-contracted laboratory, GEL Laboratories, LLC, is responsible for sample analysis by definitive analytical methodologies. START is responsible for field data analysis and data validation of laboratory-generated data.

#### 1.2 Distribution List

Copies of the final SAP will be distributed to the following persons and organizations:

- USEPA FOSC Randy Nattis, USEPA Region IX
- USEPA Region IX QA Office
- E & E START Field Team
- E & E START project files

#### 1.3 Statement of the Specific Problem

The site was identified as an AUM. Gamma radiation activity in surface soil was detected at levels up to 10 times the reported background level. Gamma radiation activity ranged from 38,560 to 962,400 counts per minute (cpm) at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 picoCuries per gram (pCi/g) in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. Gamma radiation activity and Ra-226 in soil at the site may pose an imminent and substantial threat to human health.

The USEPA determined a removal action is necessary to protect human health. In October 2012 the USEPA plans to start the excavation of 63,608 cubic yards of contaminated soil from 179.6 acres. The gamma radiation activity and Ra-226 concentration in soil left in place needs to be determined.

# 2 Site Background

#### 2.1 Site Location

AUM 32 is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico (Figure 2-1). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation. The Chapter House is approximately 1.4 miles northwest of AUM 32. AUM 32 consists of a former mine area (Latitude: 35°29'26.7576"N, Longitude: -108°1'2.7798"W) and transfer area (Latitude: 35°29'11.94"N, Longitude: 108°1'9.98"W). The mine area is bordered to the east by AUM 33. The transfer area is located approximately 0.3 mile southwest of the mine area. AUM 32 is located in a range land.

AUM 33 is located immediately east of the AUM 32 mine area (Latitude: 35°29'26.1972"N, Longitude: -108°0'59.8583"W). AUM 33 is privately owned and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation. AUM 33 is located in a range land.

Two home sites are located 0.5 mile west of AUMs 32 and 33.

#### 2.2 Site Description

The AUM 32 mine area is approximately 365,005 square feet (sf) and contains an unsecured deep shaft located in the southeastern portion, and an undetermined extent of underground workings (Weston Solutions, Inc. [Weston] 2009). The mine area is relatively flat with sparse vegetation. Available geographical information shows an ephemeral stream or river located north and south of the mine area and converges approximately 0.25 mile west of the mine area. A 10-foot deep ditch was observed to run from east to west and bounded the mine area to the north. The ditch connects to a pond located northwest of the mine area. Approximately 309,000 sf of the AUM 32 mine area has be documented to have elevated gamma radiation activity and Ra-226 concentration in soil.

The AUM 32 transfer area is approximately 267,432 sf, based on GIS data collected durong the assessment, and contains a concrete pad and a sealed vent. The transfer area is located on a slight elevation with sparse vegetation. Evidence of past water flows toward a northwest direction was observed. Approximately 323,000 sf of the area around and within AUM 32 transfer area has be documented to to have elevated gamma radiation activity and Ra-226 concentration in soil.

AUM 33 has an approximate area of 153,963 sf and contains waste piles, a wooden hopper located in the northeastern corner, and an undetermined extent of underground workings (Weston 2009). AUM 33 is relatively flat with sparse vegetation. Available geographical information show an ephemeral stream or river located north and south of AUM 33 which converges approximately 0.25 mile to the west, and two ponds located on the northeast. Evidence of water flowing through the AUM was observed. The two ponds were observed to be filled with water. Approximately 152,000 sf of the AUM 32 mine area has be documented to to have elevated gamma radiation activity and Ra-226 concentration in soil.

Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during field activities detected bedrock at 3 feet below ground surface (bgs). No residences and public structures were found within 0.25 miles of AUMs 32 and 33. The nearest resident lives approximately 0.5 mile to the west. Agricultural food production such



as livestock grazing or farming common in Navajo communities was not documented at or immediately adjacent to the AUMs; however, domestic pets, terrestrial wildlife, and animal droppings were observed.

#### 2.3 Site History

According to USEPA, portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore for national defense and energy purposes on Navajo tribal lands led to a legacy of AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston 2009).

AUMs 32 and 33 contained historical mines which were reportedly owned by Cobb Nuclear Company and were closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations was available. No visible signs of reclamation were reported.

USEPA and NNEPA interviewed a local resident who showed the location of a former transfer area southwest of the AUM 32 mine area (E & E 2012). A concrete pad where a crane was reportedly mounted was located in the potential former transfer area. The resident had relatives who formerly worked for Cobb Nuclear Company and reported rail cars transported material from the mine area towards the south and southeast directions. The reported structures were not evident in historical aerial photographs available after the July 2012 USEPA-led field activities.

Materials from the mine potentially used as building materials for residential structures may expose residents to radiation. The nearest residents reportedly used some materials (tarps and lumber) obtained from the mine (Weston 2009).

#### 2.4 Previous Investigations

A site screening was conducted at AUMs 32 and 33 which included collection of site information and gamma radiation survey data (Weston 2009). Gamma radiation activity was measured from surface soil along the initial boundary of the mine areas and along two diagonal intersecting transects from the mine areas' four corners. Gamma radiation activity measurements ranged from 10,689 to 180,367 cpm at AUM 32; and 14,322 to 140,917 cpm at AUM 33. A rock from a waste pile at AUM 33 emitted over 800,000 cpm. Gamma radiation activity was also measured from a background location which was not identified in the report. The gamma radiation activity at the background location ranged from 16,630 to 17,128 cpm. The building materials in the nearest residence had gamma radiation measurements of approximately 12,000 cpm.

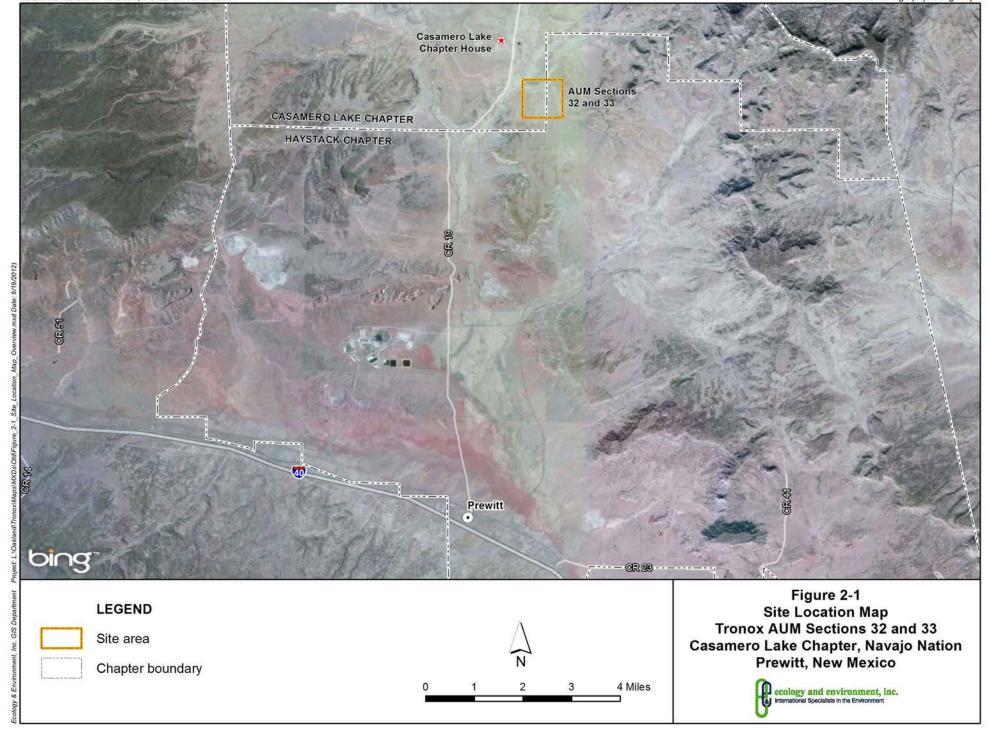
In June and July 2012, a removal assessment was conducted by USEPA and START at the site (E & E 2012). The removal assessment consisted of surface gamma radiation survey, sampling for Radium-226 (Ra-226) analysis, and home site assessment. Surface gamma radiation activity at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 cpm at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 pCi/g in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. The action level was based on background level and the preliminary remediation goal (PRG) for Ra-226 and its radioactive decay chain products (Ra-



#### 3. Project Objectives

226+D) in residential soil and an estimated excess cancer risk of 1 in 10,000 (10<sup>-4</sup>) (USEPA 2010). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. Fourteen removal areas were proposed at AUM 32 and three removal areas were proposed at AUM 33. The total proposed removal volume is 63,608 cubic yards. For the home sites, the difference between the background and measured dose rate in the structures was below 15 millirem per year which was based on an excess cancer risk of 3 x 10<sup>-4</sup>. The gamma radiation activity results inside the structures and from surface soil outside the structures within the property were below background levels. Based on the results of the removal assessment, USEPA determined a removal action is necessary at the site and no further action is warranted at the home sites.

Insert
Figure 2-1 Site Location Map



# 3 Project Objectives

#### 3.1 Data Use Objectives

Data generated from this investigation will be used to:

- Document gamma radiation activity in soil remaining in place within each removal area
- Document concentration of Ra-226 in soil remaining in place within each removal area
- Assist USEPA with decision on further action at the site.

#### 3.2 Project Task/Sampling Objectives

USEPA tasked START to support the removal action at Tronox AUM Sections 32 and 33 including confirming and documenting that soil remaining in place at removal areas at the site contains gamma radiation activity and Ra-226 concentration at or below the cleanup level. Under this task, START will complete this SAP, field activities, and a final report.

This SAP includes data quality objectives; the number, location, and type of proposed sampling; field sample collection and laboratory analytical methods and procedures; data quality assurance and validation procedures. Field activities include mobilization/demobilization, gamma radiation activity scans and soil sampling. Data collection will be conducted according to this SAP and the following objectives.

- 1. Determine whether gamma radiation activity in soil remaining in place within the removal area require removal or confirmation sampling for Ra-226 analysis.
- 2. Determine whether concentrations of Ra-226 in soil remaining in place within the removal area require removal or no further action.

#### 3.3 Cleanup Level

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated during the removal assessment to determine if gamma radiation activity measurements can be used as a field screening tool to estimate Ra-226 concentrations. Gamma radiation activity can be measured in real-time in the field while Ra-226 concentrations are determined by laboratory analysis which takes months after sampling. The results indicate there is a correlation between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and locations with gamma radiation activity measurements below 40,000 cpm using a specific paired radiation survey equipment (Equipment A1) will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012).

The cleanup level for Ra-226 in soil at the site was based on the sum of the highest background concentration of Ra-226 established for the site and the USEPA PRG of 1.21 pCi/g for residential soil based on an estimated excess cancer risk of 1 in 10,000 (10<sup>-4</sup>) for Ra-226 and its radioactive decay chain products (Ra-226+D) (USEPA 2010). Exposure pathways considered include incidental ingestion of soil, inhalation of particulates emitted from soil, external exposure to ionizing radiation, and consumption of fruits and vegetables. This standardized PRG is based on default exposure parameters and incorporate exposure factors that present reasonable maximum exposure selected to be protective of human health for most site conditions.





The cleanup levels for the removal action are presented in Table 3-1.





#### Table 3-1 Benchmarks and Data Quality Indicator Goals Gamma Radiation Activity Survey and Definitive Data for Ra-226 by EML HASL 300, 4.5.2.3 Method Tronox AUM Sections 32 and 33 Removal Action Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2200 TDD No. 02-09-12-09-0002

Analyte	Background Concentration <sup>1</sup>	Site-Specific Cleanup Level	USEPA PRG (pCi/g)	Reporting Limit	Accuracy (% Recovery for MS/ MSD)	Precision (RPD from MS/MSD and Duplicates)	Percent Completeness
Gamma	27,000 cpm	40,000 cpm	NA	0.1 cpm	NA	20%	90
radiation				with a detection			
activity <sup>2</sup>				range from 0.1			
				to 999,000 cpm			
Ra-226	0.900 pCi/g	2.11 pCi/g	1.21	1.00 (pCi/g) at	NA	35%	90
				GEL			
				Laboratories,			
				LLC			

Notes:

% – percent MS/MSD = Matrix Spike/Matrix Spike Duplicate

AUM – abandoned uranium mine NA – Not applicable

pCi/g – picocuries per gram cpm – count per minute

EML – Environmental Measurements Laboratory PRG – USEPA Preliminary Remediation Goal (August 2010)

Ra-226 – Radium isotope number 226 USEPA – U.S. Environmental Protection Agency HASL – Health and Safety Laboratory RPD – Relative Percent Difference

Background gamma radiation activity and Ra-226 concentration in soil were determined during the removal assessment (E & E 2012).

All field instruments will be included in the quality control program to document that the instruments are operating within specified control limits. The background and gamma source control limits will be established based on plus or minus 20 percent of the respective average activity rates, determined according to the instrument FOPs.

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#### 3.4 Data Quality Objectives

The DQO process, as set forth in the USEPA Guidance on Systematic Planning Using the Data Quality Objectives Process, USEPA/240/B-06/001 (USEPA 2006), was followed to establish the DQO for this project. An outline of the process and the outputs for this project are included in Appendix A.

#### 3.5 Data Quality Indicators (DQIs)

Data quality indicators (DQIs) are defined as: precision, accuracy, representativeness, completeness, comparability, and method detection limits. The DQIs for this project were developed following the guidelines in the USEPA *Requirements for Quality Assurance Project Plans* (USEPA 2001). All sampling procedures are documented in Sections 6.2 and 6.3. Standard operating procedures will be followed to ensure representativeness of sample results by obtaining characteristic samples. Approved USEPA methods and standard reporting limits will be used whenever possible. All data not rejected will be considered complete. Table 3-1 documents the site-specific DQI goals for Gamma radiation activity and Ra-226.

#### 3.6 Schedule of Sampling Activities

Field activities will begin on October 8, 2012 and continue for up to 42 days.

#### 3.7 Special Training Requirements/Certifications

The operation of the field analytical instruments requires specialized training that will be administered, prior to mobilization, to all START personnel scheduled to be on site.

Field sampling personnel should be trained and have experience with soil sampling at hazardous waste sites while wearing appropriate protective equipment. One field sampler will be trained and familiar with Global Positioning System (GPS) data collection. All sampling personnel will have appropriate training that complies with 29 Code of Federal Regulations 1910.120. The site-specific health and safety plan for this project is included in Appendix B.

Data validation requires specialized training and experience. The START QC Coordinator will determine and verify a qualified data validation resource prior to data validation.

# 4 Sampling Rationale and Design

The sampling rationale and design was developed under the direction of the USEPA FOSC and START Program Manager, and based on information from other USEPA AUM sites.

#### 4.1 Removal Areas

The removal areas are differentiated by the depth of soil recommended to be removed based on subsurface soil sampling. Fourteen removal areas were proposed at AUM 32 and three removal areas were proposed at AUM 33. The total proposed removal volume is 63,608 cubic yards. The removal areas are shown in Figures 4-1 to 4-4.

Gamma radiation activity in soil remaining in place within each removal area will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter mounted 6 inches from the ground surface. The VIPER system and geographical information system will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 to 6 feet apart which will provide 100 percent characterization of the floor of the excavation. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. The surveyor will walk at a pace of 3 feet per second.

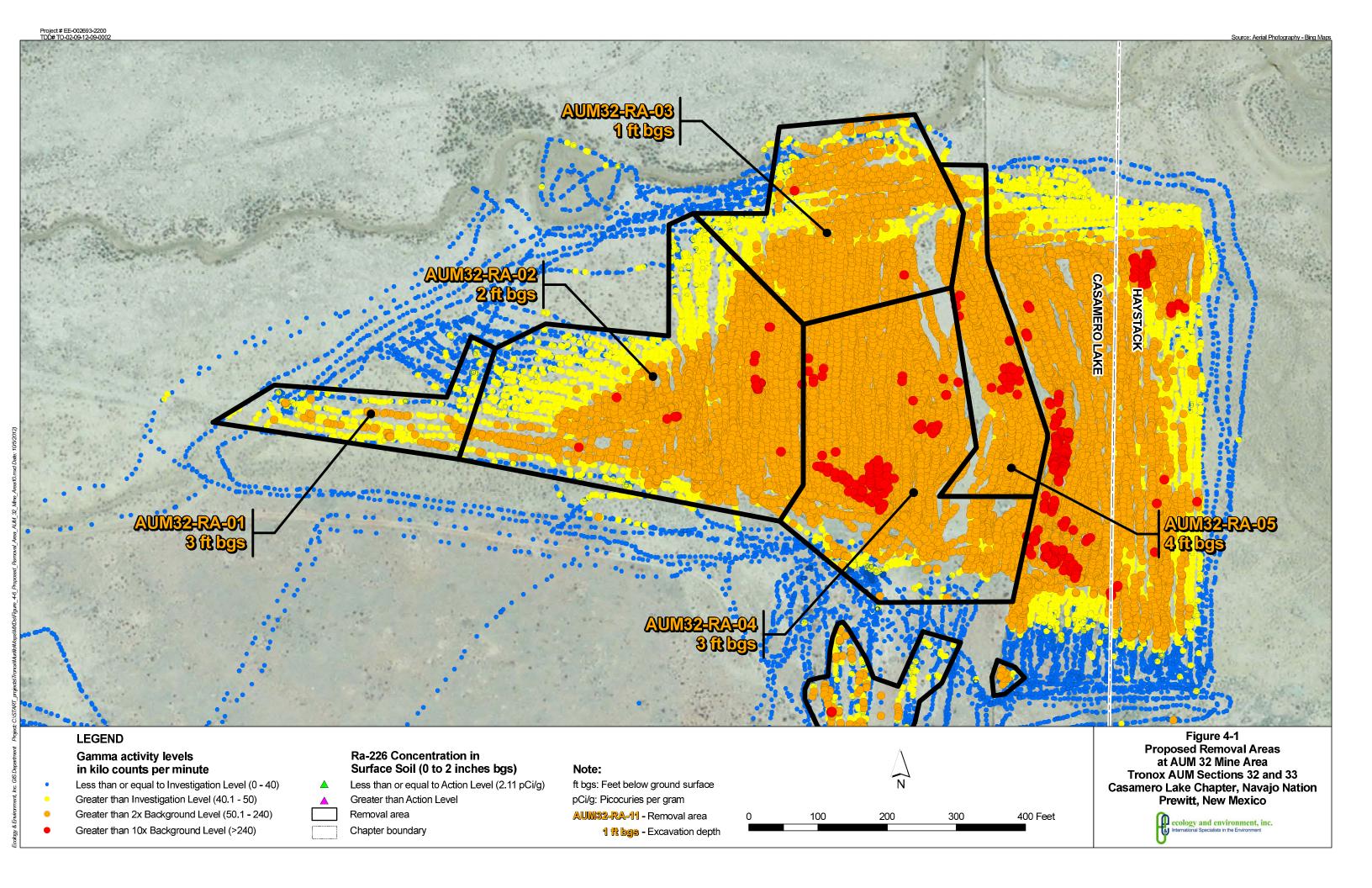
Soil samples will be collected at 0 to 2 inches bgs from the floor of the excavation footprint at three locations within each removal area and analyzed for Ra-226 by the Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (Department of Energy [DOE] 1990). The concentrations of Ra-226 in soil will be compared with the 1-minute gamma radiation activity measurements to show the correlation between gamma radiation activity and Ra-226 concentrations in soil.

#### 4.2 Analytes of Concern

Gamma radiation activity in surface soil will be measured in cpm. Gamma radiation activity was correlated with Ra-226 concentration in surface soil during the removal assessment and will be used as a field screening tool during the removal action.

Confirmation soil samples will be analyzed for Ra-226.

Insert
Figure 4-1 Removal Areas and Confirmation Sampling Locations at AUM 32 Mine Area

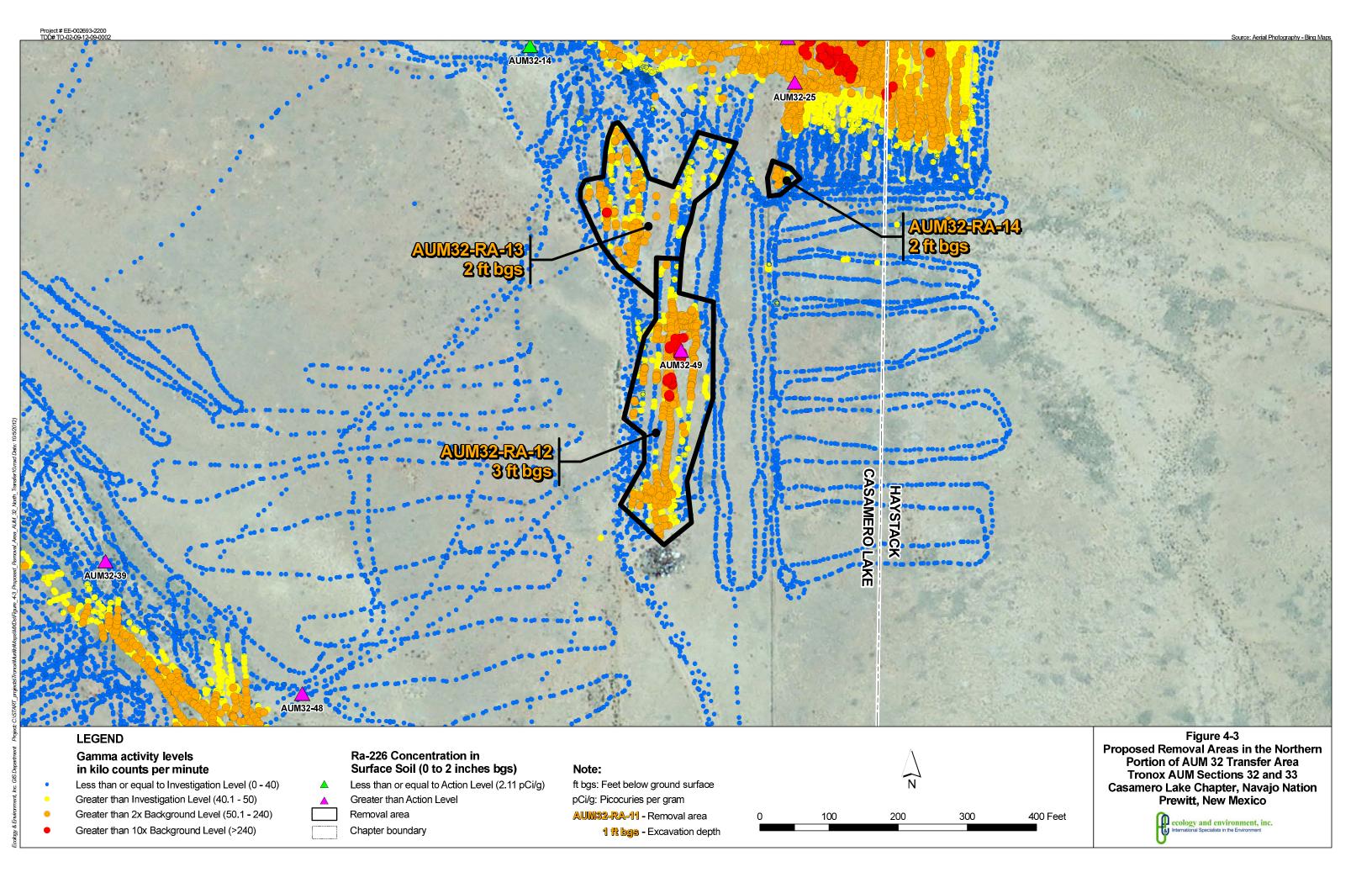


Insert

Figure 4-2 Removal Areas and Confirmation Sampling Locations at the Southern Portion of AUM 32 Transfer Area

Insert

Figure 4-3 Removal Areas and Confirmation Sampling Locations at the Northern Portion of AUM 32 Transfer Area



Insert
Figure 4-4 Removal Areas and Confirmation Sampling Locations at AUM 33

# 5 Request for Analyses

Gamma radiation activity will be measured over the entire floor surface of each removal area. Confirmation soil samples from 0 to 2 feet bgs from the floor surface of each removal area will be analyzed for Ra-226 concentration by the START-contracted laboratory.

The following sections describe these analyses.

#### 5.1 Field Analysis

Gamma radiation activity in surface soil and floor surfaces will be measured in the field using a paired Ludlum Model 2241 meter and a 44-20 (3x3) detector. Operational checks will be conducted on the paired meter and detector before the field activities using a check source with 1 microcurie of Cesium-137 based on previous AUM sites. The optimal high voltage setting for the instrument will be set using a Fluke voltage meter. The meter used for the soil survey will be linked to a VIPER system for geospatial information collection and analysis.

To provide quality control for the field analytical effort, the following measures will be utilized:

- Analytical precision and sensitivity of the gamma radiation activity survey equipment
  will be established before beginning the field measurements and will be verified
  throughout the field survey through operational and background checks.
- Whenever possible, the same paired VIPER-linked meter and detector used to establish the relationship between gamma radiation activity and Ra-226 concentrations in soil will be used for all surveys conducted at the site.

# 5.2 Laboratory Analysis

Soil samples will be analyzed for Ra-226 by EML HASL 300, 4.5.2.3 Method (DOE 1990). Soil samples will be submitted to GEL Laboratories, LLC located at 2040 Savage Road, Charleston, South Carolina 29407. Sample containers, preservatives, holding times, and estimated number of soil confirmation and quality control samples are summarized in Table 5-1.

To provide quality control for the analytical program, the following measures will be utilized:

- Duplicate samples will be collected from ten percent of the soil sampling locations or one per sample design group. Duplicate soil samples will be collected as a 50/50 split of the sample after collection and homogenization.
- If non-dedicated sampling equipment is used to collect soil samples at the site, a rinsate blank will be collected at a rate of one per day to evaluate decontamination procedures at the site. The rinsate blank will be collected by pouring deionized water over the decontaminated sample collection device (e.g., trowel) and capturing the water in the specified sample container. The method for water analysis is Radium 226 by USEPA 903.1 modified.



#### 5. Request for Analyses

#### Table 5-1 Sampling and Analysis Summary Tronox AUM Sections 32 and 33 Removal Action Prewitt, McKinley County, New Mexico

E & E Project No. EE-002693-2200

TDD No. 02-09-12-09-0002

Method	Ra-226 by EML HASL 300, 4.5.2.3 Method	
Sample Container	4 ounce plastic soil jars	
Preservation	None	
Analysis Holding Time	6 Months	
Estimated Number of Unique Discrete Samples	45 surface soil samples	
Estimated Number of Duplicate Samples	5	
Minimum Total Site Sample Analyses	50	
Equipment Rinse Blanks (if	non-dedicated equipment is used)	
Method	Ra-226 by USEPA 903.1 modified Radon Emanation Method	
Sample Container	500 milliliter plastic bottle	
Preservation	None	
Analysis Holding Time	14 days	

Note:

AUM – abandoned uranium mine

Number of Samples

EML – Environmental Measurements Laboratory

HASL – Health and Safety Laboratory

Ra-226 – Radium isotope number 226

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1 per day (20)

# 6 Field Methods and Procedures

The following sections describe the procedures and equipment that will be used during the field activities.

#### 6.1 Field Procedures

#### 6.1.1 Standard Operating Procedures and Equipment

The equipment listed below may be utilized to obtain environmental samples from the respective media according to the following sampling standard operating procedures (SOPs) or their equivalent:

- FOP 1, Radiation Scanning Survey
- FOP 3, Ludlum Model 2241
- FOP 5, Ludlum Model 44-20
- For the VIPER system, procedures will be provided by ERT
- Ecology and Environment Inc. SOP # ENV 3.13: Soil Sampling
- Ecology and Environment Inc. SOP# ENV 3.15: Sampling Equipment Decontamination

The following is a partial list of equipment that may come in contact with samples:

- Trowel
- Plastic sample jars
- Disposable nitrile gloves

#### **6.1.2 Equipment Maintenance**

Field instrumentation for the collection of soil samples will be operated, maintained, and have operational checks conducted by the sampling team according to the SOPs listed in Section 6.1.1 or their equivalent. Field instrumentation utilized for health and safety purposes will be operated, maintained, and have operational checks conducted by the sampling team according to the manufacturer's instruction. Operational checks and field use data will be recorded in the instrument or field logbooks.

#### 6.1.3 Inspection/Acceptance Requirements for Supplies and Consumables

There are no project-specific inspection/acceptance criteria for supplies and consumables. It is standard operating procedure that personnel will not use broken or defective materials; items will not be used past their expiration date; supplies and consumables will be checked against order and packing slips to verify the correct items were received; and the supplier will be notified of any missing or damaged items.

#### 6.1.4 Logbooks

Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. A separate logbook will be maintained for each project. Logbooks are bound with



#### 6. Field Methods and Procedures

consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions. The following information will be recorded, if applicable, during the collection of each sample:

- Sample location and description
- Site sketch showing sample location and measured distances
- Sampler's name(s)
- Date and time of sample collection
- Type of sample (matrix)
- Type of sampling equipment used
- Onsite measurement data (e.g., Background radiation measurements)
- Field observations and details important to analysis or integrity of samples (rain, odors, etc.)
- Type(s) of preservation used
- Field instrument reading (such as micro-Roentgen readings for health and safety purposes, etc.)
- Shipping arrangements (air bill numbers)
- Receiving laboratory

START team members will be on site performing different duties related to sample collection, processing, and analysis. Each logbook will document the information relevant to the site radiation activity, and at a minimum will include:

- Team members and their responsibilities
- Time of activities
- Deviations from sampling plans, site safety plans, and SAP procedures
- Levels of safety protection
- Operational check information
- Analytical data

#### 6.1.5 Photographs

Photographs will be taken at representative sampling locations and at other areas of interest on site. They will serve to verify information entered in the field logbook. When a photograph is taken, the following information will be written in the logbook or will be recorded in a separate field photography log:

- Time, date, location, and, if appropriate, weather conditions
- Description of the subject photographed
- Name of person taking the photograph



#### 6.1.6 Electronic Sample Logging

The sampling team may utilize field management software to prepare sample labels and chain-of-custody forms. Blank sample labels and chain-of-custody forms will also be available.

The following information should be entered for each sample after collection:

- Sample name
- Sample date and time
- Number of sample bottles
- Type of preservation
- Analyses

In addition to these items, the software may also be used to keep track of other information such as sample depth, field measurements, and split samples.

The field team will generate chain-of-custody forms for each cooler of samples packaged and sent to a laboratory. Each chain-of-custody form will refer to the shipping method and tracking number. Printed chain-of-custody forms will be submitted to the laboratory with the samples.

The use of field management software will require that the field team have access to a computer, a printer, computer paper, and labels while in the field. The field data manager will be responsible for implementing the software.

#### 6.1.7 Mapping Equipment

Sample points and site features will be located and documented with a GPS unit. The GPS will be used to assign precise geographic coordinates to sample locations on the site. GPS mapping will be done by personnel trained in the use of the equipment and will be completed according to the manufacturer's instructions. Expected output from the use of GPS mapping will be site maps with sample locations and major site features.

# 6.2 Gamma Radiation Survey Procedures

The survey equipment for measuring gamma radiation activity consists of a paired Ludlum Model 44-20 (3x3) detector and a 2241 meter linked to a VIPER system which will have operational checks conducted before field activities begin according to FOPs 1, 3, and 5. Performance of the radiation survey equipment will be verified throughout the field activities through operational checks and background checks as necessary. Whenever possible, the same paired gamma activity survey system will be used for all surveys conducted at the site.

The paired Ludlum Model 44-20 (3x3) detector and 2241 meter linked to a VIPER system will be mounted 6 inches from the ground surface of the excavation floor. The VIPER system and GIS will be used for geospatial information collection and analysis. Real-time *in situ* surface soil survey will consist of 3- to 6-foot wide transects covering 100 percent of the survey area at a pace of 3 feet per second. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. If an immovable obstruction is encountered during the survey it will



not be moved, and the scanning survey will be performed around the feature. Gamma radiation survey will be conducted within each removal area.

Gamma radiation activity measurements will be used as a field screening tool. The relationship between 1-minute gamma radiation activity measurements and co-located surface soil Ra-226 sample results was evaluated during the removal assessment. The results indicated that locations with gamma radiation activity measurements below 40,000 cpm using a specific paired radiation survey equipment (Equipment A1) will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012).

#### 6.3 Soil Sampling Procedures

Confirmation soil samples for Ra-226 analysis will be collected from the excavation floor of each removal area determined to be below the cleanup level based on gamma radiation activity measurements. Confirmation soil sample locations in each removal area were determined using VSP. Surface soil sample locations will be located in the field using a GPS unit pre-loaded with the GIS-assigned coordinates and marked with a flag.

Discrete surface soil samples will be collected at 0 to 2 inches bgs. Surface soil samples will be collected using a stainless-steel trowel and placed into a 4-ounce plastic jar. If present, non-soil material including rocks larger than about ½-inch median diameter will be removed from the soil sample. Sample jars will be stored in a cooler according to the laboratory requirements in Table 5-1. Samples will be shipped to the laboratory for Ra-226 analysis using the EML HASL 300 4.5.2.3 method at the end of field activities. Sampling equipment will be decontaminated after every sample according to Section 6.5. A maximum of 45 surface soil samples will be collected from the site.

All sample locations will be recorded in the field logbook as sampling is completed. Each field sampling team will document each individual sampling location in the logbook, which includes: the site name, where the sample was collected with a representative sketch of the area, GPS coordinates of the sample location, date, time, sample identification (ID), sampling team members, and photographs taken.

#### 6.4 Decontamination Procedures

Decontamination activities will be conducted by START according to E & E SOP #3.15. All non-dedicated sample-handling devices will be decontaminated by non-phosphate detergent and tap water wash using a brush to scrub solids from the surface as necessary, and distilled water rinse; or non-chemical moist wipes.

# 7 Disposal of Investigation-Derived Waste

In the process of collecting environmental samples at this site, several different types of potentially contaminated investigation-derived wastes (IDW) will be generated, including the following:

- Used personal protective equipment (PPE)
- Disposable sampling equipment
- Decontamination fluids

The USEPA's National Contingency Plan requires that management of IDW generated during site investigations comply with Applicable or Relevant and Appropriate Requirements s (ARARs) to the extent practicable. This sampling plan will follow the Office of Emergency and Remedial Response Directive 9345.3-02 (USEPA 1991), which provides the guidance for management of IDW during site investigations. Listed below are the procedures that will be followed for handling IDW. The procedures are flexible enough to allow the site investigation team to use its professional judgment on the proper method for the disposal of each type of IDW generated at each sampling location.

- Used PPE and disposable sampling equipment will be scanned for elevated gamma radiation activity using a 3x3 or pancake detector. PPE and other disposable items less than 2 to 3 times background gamma radiation activity will be double-bagged in plastic trash bags and disposed of as municipal waste. These wastes are not considered hazardous and can be sent to a municipal landfill. Any PPE or dedicated equipment that is to be disposed of that can still be reused will be rendered unusable before disposal.
- Decontamination fluids which may consist of water with site materials and/or non-phosphate detergent will be placed in the highest contaminated area that will not drain from the site according to standard practice at similar sites.

# 8 Sample Identification, Documentation, and Shipment

#### 8.1 Sample Nomenclature

For survey location data using the VIPER system each measurement will have a unique geospatial coordinate.

A unique, identifiable name will be assigned to each sample. Samples will be identified according to the following nomenclature:

[Sample Description]-[Sample Number] Where:

Sample Description – Removal Area ID, for example "AUM32-RA01" Sample Number – Number representing the specific sampling location where the sample was collected starting with 01.

For example, the first confirmation soil sample collected at AUM 32 Removal Area 01 will be identified as follows:

AUM32-RA01-01

Field duplicate samples will have the same designations as their originals except the sample number will be preceded by a "1" thus, the field duplicate for the above examples will be AUM32- RA01-101.

# 8.2 Container, Preservation, and Holding Time Requirements

All sample containers will be delivered by the laboratory to START in a pre-cleaned condition. Container, preservation, and holding time requirements are summarized in Table 5-1.

# 8.3 Sample Labeling, Packaging, and Shipping

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. Sample labels will be affixed to the sample containers and will contain the following information:

- Sample number
- Date and time of collection
- Site name
- Analytical parameter and method of preservation

Samples will be stored in a cooler in the custody of site personnel at all times or in a secure location on site pending shipment to the laboratory after the field activities.

The procedures for shipping soil samples are:

■ If ice is used then it will be packed in double zip-lock plastic bags.



#### 8. Sample Identification, Documentation and Shipment

- The drain plug of the cooler will be sealed with tape to prevent melting ice from leaking.
- The bottom of the cooler will be lined with bubble wrap to prevent breakage during shipment.
- Screw caps will be checked for tightness.
- Coolers will have custody seals affixed so as to prevent opening of the container without breaking the seal.
- All glass sample containers will be wrapped in bubble wrap.
- All containers will be sealed in zip-lock plastic bags as necessary.

All samples will be placed in coolers with the appropriate chain-of-custody forms. All forms will be enclosed in plastic bags and affixed to the underside of the cooler lid. If samples require refrigeration during shipment then bags of ice will be placed on top of and around samples. Empty space in the cooler will be filled with bubble wrap or other appropriate packaging material to prevent movement and breakage during shipment. Each cooler will be secured with a custody seal and will be taped shut with packing or strapping tape.

Samples will be shipped for immediate delivery to the contracted laboratory. Upon shipping, the laboratory will be notified of the following:

- Sampling contractor's name
- The name of the site
- Shipment date and expected delivery date
- Total number of samples, by matrix and the relative level of contamination for each sample (i.e., low, medium, or high).
- Carrier; air bill number(s), method of shipment (e.g., priority)
- Irregularities or anticipated problems associated with the samples
- Number of coolers or packages shipped

# 8.4 Chain-of-Custody Forms and QA/QC Summary Forms

A chain-of-custody form will be maintained for all samples to be submitted for analysis, from the time the sample is collected until its final disposition. Every transfer of custody must be noted and a signature affixed. Corrections on sample paperwork will be made by drawing a single line through the mistake and initialing and dating the change. The correct information will be entered above, below, or after the mistake. When samples are not under the direct control of the individual responsible for them, they must be stored in a container sealed with a custody seal. The chain-of-custody form must include the following:

- Site name
- Sample identification numbers
- Sample date and time
- Number and volume of sample containers



#### 8. Sample Identification, Documentation and Shipment

- Required analyses
- Signature and name of samplers
- Signature(s) of any individual(s) with control over samples
- Note(s) indicating special holding times and/or detection limits

The chain-of-custody form will be completed and sent with the samples for each laboratory and each shipment. Each sample cooler should contain a chain-of-custody form for all samples within the sample cooler.

# 9 Quality Assurance and Control

#### 9.1 Field Quality Control Samples

QA/QC samples to be collected during this sampling are listed in Table 5-1 and described in the following subsections. QA/QC described in the following sections pertains to samples collected for laboratory analysis to obtain definitive data and do not pertain to field measurements. QA/QC relevant to field measurement data is described in instrument FOPs and discussed in section 5.1.

#### 9.1.1 Assessment of Field Contamination (Blanks)

Equipment rinsate blanks will be collected from non-dedicated equipment such as stainless steel trowels are used to collect samples, at a rate of one per day to evaluate field decontamination procedures. Equipment rinsate blank consists of a sample of analyte-free water passed through or over a decontaminated sampling device into a 500 milliliter plastic bottle. A sample of the analyte-free water (i.e., distilled water) used for decontamination will also be sent to the laboratory.

#### 9.1.2 Assessment of Sample Variability (Field Duplicate or Co-located Samples)

Duplicate soil samples will be collected at selected sample locations. These locations will be chosen randomly in the field and will be collected at a rate of 1 for every 10 field samples. The duplicate sample will be obtained by splitting the homogenized sample collected from the soil location. The duplicate sample will be placed in a 4-ounce plastic jar and labeled accordingly.

#### 9.1.3 Laboratory Quality Control Samples

Analyses for radioisotopes do not typically have MS/MSD requirements; therefore, none will be performed.

#### 9.1.4 Confirmation Samples

The samples submitted to the laboratory for definitive analysis will be used to establish and/or document the comparability and correlation between field screening and laboratory data. Results of the confirmation samples will determine if the cleanup goal was met.

# 9.2 Analytical and Data Package Requirements

It is required that all samples be analyzed according to the methods listed in Table 5-1. The laboratory is required to supply documentation to demonstrate that their data meet the requirements specified in the method. Since the Ra-226 determination requires a 21-day ingrowth period prior to analysis, the preliminary results will be delivered to START within 4 weeks of sample delivery. A complete analytical data package will be required from the analytical laboratory 30 working days after sample delivery. The laboratory will also provide all data electronically in a Microsoft Excel-compatible format or delimited text file in the format specified for Scribe. The data validator will provide a full validation data package to the START PM within 15 days after receipt of complete analytical data package from the laboratory.

All field measurements and QA/QC information will be documented in log books, field forms, and spreadsheets or may be directly downloaded into a database.



Deliverables for this project must meet the guidelines in USEPA Region IX's *Laboratory Documentation Requirements for Data Evaluation, R9/QA/00.4.1* (USEPA 2001). The following data requirements specify and emphasize general documentation requirements and are not intended to supersede or change requirements of each method.

- A copy of the chain-of-custody, sample log-in records, and a case narrative describing the analyses and methods used.
- Analytical data (results) for up to three significant figures for all samples, method blanks, MS/MSD, Laboratory Control Samples (LCS), duplicates, Performance Evaluation samples (if applicable), and field QC samples.
- QC summary sheets/forms that summarize the following:
  - MS/MSD/LCS recovery summary
  - Method/preparation blank summary
  - Initial and continuing calibration summary (including retention time windows)
  - Sample holding time and analytical sequence (i.e., extraction and analysis)
  - Calibration curves and correlation coefficients
  - Duplicate summary
  - Detection limit information
- Analyst bench records describing dilution, sample weight, percent moisture (solids), sample size, sample extraction and cleanup, final extract volumes, and amount injected.
- Standard preparation logs, including certificates of analysis for stock standards.
- Detailed explanation of the quantitation and identification procedure used for specific analyses, giving examples of calculations from the raw data.
- The final deliverable report consisting of sequentially numbered pages.

# 9.3 Data Management

Data collected during the removal assessment will consist of field and laboratory data. Field activities and sample information will be documented in a logbook as discussed in Section 6.1.4. Field and laboratory data including gamma radiation measurements, Ra-226 sample results, and location coordinates, will be loaded in Scribe. Electronic data will be managed as described in the data management plan. All data including logbook, complete analytical and validation data packages, photographs, and electronic data will be archived by START. The laboratory data summary and validation reports will be included in the final report submitted to USEPA.

#### 9.4 Data Validation

Data validation will be performed by START or their subcontractor according to the *USEPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1* (USEPA 2001).

The standard data quality review requirements of a Tier 2 validation of 100 percent of the data (as defined in *Requirements for Quality Assurance Project Plans* [USEPA 2001]) will satisfy the

#### 9. Quality Assurance and Control (QA/QC)

data quality requirements for this portion of the project. Upon completion of validation, data will be classified as one of the following: acceptable for use without qualifications, acceptable for use with qualifications, or unacceptable for use.

If during or after the evaluation of the project's analytical data it is found that the data contain excess QA/QC problems or if the data do not meet the DQI goals, then the independent reviewer may determine that additional data evaluation is necessary. Additional evaluation may include USEPA Region IX Superfund Data Evaluation/Validation Guidance R9QA/006.1 for evaluation Tier 3.

To meet evaluation and project requirements, the following criteria will be evaluated during a Tier 2 evaluation:

- Data package completeness
- Laboratory QA/QC summaries
- Holding times
- Blank contamination
- Matrix related recoveries
- Field duplicates
- Random data checks
- Preservation and holding times
- Initial and continuing calibration
- Blank analyses
- Interference check samples
- Laboratory control samples
- Duplicate sample analysis
- Matrix spike sample analyses
- Sample serial dilution
- Field duplicate/replicate
- Overall assessment of data.

Upon completion of evaluation, an analytical data evaluation Tier 2 review report will be delivered to the project manager, and the data will be classified within the report as one of the following:

acceptable for use without qualifications



- acceptable for use with qualifications
- unacceptable for use

The data with applicable qualifications will be attached to the report. Unacceptable data may be more thoroughly examined to determine whether corrective action could mitigate data usability.

#### 9.5 Field Variances

As conditions in the field may vary, it may become necessary to implement minor modifications to this plan. When appropriate, the START QA Coordinator and the USEPA FOSC will be notified of the modifications and a verbal approval obtained before implementing the modifications. Modifications to the original plan will be recorded in site records and documented in the final report.

#### 9.6 Assessment of Project Activities

#### 9.6.1 Assessment Activities

The following assessment activities will be performed by the START:

- All project deliverables (SAP, Data Summaries, Data Validation Reports, Removal Action Report) will be peer-reviewed by START prior to submission to USEPA. In time-critical situations, the peer review may be concurrent with the release of a draft document to USEPA.
- The START QA Coordinator will review project documentation such as logbooks and chain-of-custody forms to ensure the SAP was followed and that sampling activities were adequately documented. The START QA Coordinator will document deficiencies, and the START PM will be responsible for corrective actions.

#### 9.6.2 Project Status Reports to Management

It is standard procedure for the START PM to report to the USEPA FOSC any issues, as they occur, that arise during the course of the project that could affect data quality, data use objectives, the project objectives, or project schedules. As requested by USEPA, START will provide unvalidated data as they are received from the laboratory.

#### 9.6.3 Reconciliation of Data with DQOs

Assessment of data quality is an ongoing activity throughout all phases of a project. The following outlines the methods to be used by START for evaluating the results obtained from the project.

Review of the DQO outputs and the sampling design will be conducted by the START QA Coordinator prior to sampling activities. The reviewer will submit comments to the START PM for action, comment, or clarification. This process will be iterative.

A preliminary data review will be conducted by START. The purpose of this review is to look for problems or anomalies in the implementation of the sample collection and analysis procedures and to examine QC data for information to verify assumptions underlying the DQO and the SAP.

# 10 References

- Bureau of Indian Affairs, Department of Energy, Nuclear Regulatory Commission, USEPA, and Indian Health Service. 2008. *Health and Environmental Impacts of Uranium Contamination in the Navajo Nation Five-Year Plan*. June 9.
- Ecology and Environment, Inc. (E & E). Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico. September 2012.
- U.S. Department of Energy. 1990. EML Procedures Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621.
- United States Environmental Protection Agency (USEPA). 1991. *Management of Investigation-Derived Wastes During Site Inspections*, Office of Emergency and Remedial Response, OERR Directive 9345.3-02, May.
- USEPA, 2001. *Laboratory Documentation Requirements for Data Evaluation* (USEPA Region IX R9/QA/00.4.1), March.
- USEPA, 2001. Requirements for Quality Assurance Project Plans (USEPA QA/R 5, USEPA/240/B 01/003), March.
- USEPA, 2002. Guidance on Choosing a Sampling Design for Environmental Data Collection (USEPA QA/G 5S, USEPA/240/R 02/005), December.
- USEPA, 2005. *Uniform Federal Policy for Implementing Environmental Quality System* (USEPA/505/F-03/001), March.
- USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA/240/B-06/001), February.
- USEPA. 2010. *Preliminary Remediation Goals for Radionuclides*. August. Available online at http://epa-prgs.ornl.gov/radionuclides/download.html
- Weston Solutions Inc., 2009. Navajo Nation Abandoned Uranium Mine Site Screen Report Section 32 AUM Site, Navajo AUM Eastern Region, May.

# A Data Quality Objective Process Document

# UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, REGION 9 DATA QUALITY OBJECTIVES FOR TRONOX ABANDONED URANIUM MINE SECTIONS 32 AND 33 REMOVAL

#### STEP 1.

#### THE PROBLEM

#### **Background**

The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E) Superfund Technical Assessment and Response Team (START) to support a removal action at Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 (site). The site is located approximately 1 mile east of County Road 19, Prewitt, McKinley County, New Mexico. The site consists of the mine area (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W) and transfer area (Latitude: 35° 29'11.94"N, Longitude: 108°1'9.98"W) at AUM 32, and AUM 33 (Latitude: 35°29'26.1972"N, Longitude: -108°0'59.8583"W). AUM 32 is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation while AUM 33 is privately owned and is part of the Casamero Lake and Haystack Chapters of the Navajo Nation.

According to USEPA, portions of the Navajo Nation are located on geologic formations rich in radioactive uranium ores. Beginning in the 1940s, widespread mining and milling of uranium ore for national defense and energy purposes on Navajo tribal lands led to a legacy of AUMs. Cobb Nuclear Company operated mines in the Casamero Lake Chapter area (Weston Solutions, Inc. [Weston], Navajo Nation Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region, May 2009).

The site contained historical mines reportedly owned by Cobb Nuclear and were closed due to a fatality. No other information on historical ownership of the mine and mining operations were available. The AUM 32 transfer area was located by USEPA and Navajo Nation Environmental Protection Agency after an interview with a local resident who had relatives who formerly worked for Cobb Nuclear Company. The AUM 32 mine area is approximately 365,005 square feet (sf) and contains an unsecured deep shaft located in the southeastern portion, and an undetermined extent of underground workings. The AUM 32 transfer area is located southwest of the AUM 32 mine area, approximately 267,432 sf, and contains a concrete pad and a sealed vent. AUM 33 has an approximate area of 153,963 sf and contains waste piles, a wooden hopper located in the northeastern corner, and an undetermined extent of underground workings.

In June and July 2012, a removal assessment was conducted by USEPA and START at the site. The removal assessment consisted of surface gamma radiation survey, sampling for Radium-226 (Ra-226) analysis, and home site assessment. Surface gamma radiation activity at the site was detected above background levels. Gamma radiation activity ranged from 38,560 to 962,400 counts per minute (cpm) at the AUM 32 mine area, 16,880 to above 1,000,000 cpm at the AUM 32 transfer area, and 33,410 to above 1,000,000 cpm at AUM 33. Rocks and potential buried rocks had gamma radiation activity over 500,000 cpm. Ra-226 concentrations were detected above the action level of 2.11 picoCuries per gram (pCi/g) in surface soil and down to 3 feet below ground surface (bgs). Ra-226 was detected up to 300 pCi/g. The action level was based on background level and the preliminary remediation goal for Ra-226 and its radioactive decay chain products (Ra-226+D) in

residential soil and an estimated excess cancer risk of 1 in 10,000 ( $10^{-4}$ ) (USEPA, *Preliminary Remediation Goals for Radionuclides*. August 2010). Rocks and mine waste material were observed at locations with elevated gamma radiation activity and Ra-226 concentrations. Fourteen removal areas were proposed at AUM 32 and three removal areas were proposed at AUM 33. The total proposed removal volume is 63,608 cubic yards. For the home sites, the difference between the background and measured dose rate in the structures was below 15 millirem per year which was based on an excess cancer risk of 3 x  $10^{-4}$ . The gamma radiation activity results inside the structures and from surface soil outside the structures within the property were below background levels. Based on the results of the removal assessment, USEPA determined a removal action is necessary at the site and no further action is warranted at the home sites.

USEPA will conduct a removal action at the site on October 8, 2012. The removal action is an interim action which consists of excavating soil, stockpiling removed soil at the AUM 32 mine area, and stabilizing the stockpiles to protect human health. USEPA directed START to confirm and document that soil remaining in place at removal areas at the site contain gamma radiation activity and Ra-226 concentration at or below the cleanup level.

#### **Planning Team**

Primary Decision Maker: USEPA Task Monitor/Federal On-Scene Coordinator Randy

Nattis

Plan Development: START and the USEPA Task Monitor

Plan Approval: USEPA Task Monitor

On-Scene Assistance: USEPA Task Monitor, START, USEPA Emergency

Response Team (ERT), Emergency and Rapid Response

Services (ERRS) contractor

Potential

On-Scene Assistance: Navajo Nation representative

Supplemental Off-Site

Support: The START response team managers, START quality

assurance (QA) manager, START response Readiness Coordinator, START analytical service provider, START Radiological Assessment Adjunct, and USEPA Region 9

equipment warehouse

The names and affiliations of the actual planning team will be documented in the field logbook or in the sampling and analysis plan (SAP).

#### **Conceptual Site Model**

Historical mining at the site may have released technologically-enhanced, naturally-occurring radioactive materials, specifically uranium and its decay products, to surface soil. Results of the removal assessment showed elevated gamma radiation activity and Ra-226 concentrations in surface soil and down to 3 feet bgs.

Soil is the primary media of concern in this removal action. Surface water was not observed at or within the influence of the site; however, available geographical information show an ephemeral stream or river located north and south of the site which converges approximately 0.25 mile west of the site. Evidence of water flowing through the site was observed during the removal assessment. A ditch runs along northern boundary of the site and connects to a pond located northwest of the site. Two ponds filled with water are located northeast of the site. Groundwater depth and information on nearby water wells used for drinking water were not available. Soil borings during the removal assessment detected bedrock at 3 feet bgs.

No residences and public structures were found within 0.25 miles of the site. The nearest resident lives approximately 0.5 mile to the west of the site. Any dust generated during the removal action is not expected to impact the nearest resident. Agricultural food production such as livestock grazing or farming common in Navajo communities was not documented at or immediately adjacent to the site; however, domestic pets, terrestrial wildlife, and animal droppings were observed.

#### **Exposure Scenario**

Potential exposure pathways include direct exposure of human receptors to gamma radiation and Ra-226 in soil at the site. Receptors may also be exposed through ingestion, dermal contact, and inhalation of other mine-related materials in soil, air, and water affected by the site.

The open shaft, which is approximately 20 feet in diameter, poses a physical hazard at the site. Current potential human receptors include nearby residents located less than 0.5 mile from the site.

#### **Resources**

The planning and preparation are administered and implemented by the USEPA Region 9 staff and their supporting START contractors. All site-specific planning activities are under the direction of the USEPA Task Monitor.

This is a removal action under the technical direction of the USEPA Task Monitor. Initial labor resources include:

- The responding USEPA Task Monitor, who will oversee all data collection and operations related to the time-critical response.
- START personnel
- USEPA ERT
- ERRS personnel

Analytical service resources include the following:

- Real-time field radiation survey will be performed by START.
- START analytical service provider will analyze collected samples.

START's initial budget for this time-critical response is \$207,839.24.

#### **Resource Constraints**

The use of non-routine radiation screening or other field instruments and equipment will require training or experienced personnel.

Data Quality Objectives for Fronox Aoin Sections 32 and 33 Nemoval
Availability of USEPA-owned radiation screening equipment is dependent on other ongoing USEPA projects requiring similar resources.

#### STEP 2.

#### THE DECISION

#### **Principal Study Questions**

- 1. What is gamma radiation activity in soil remaining in place within each removal area?
- 2. What is Ra-226 concentration in soil remaining in place within each removal area?

#### Actions that Could Result from the Resolution of Study Questions

#### **Question 1**

If the gamma radiation activity in soil remaining in place within the removal area exceeds 40,000 cpm then USEPA may initiate or order further excavation of soil within the removal area.

If the gamma radiation activity in soil remaining in place within the removal area is at or below 40,000 cpm then soil samples will be collected to confirm Ra-226 concentrations are at or below the cleanup level.

#### **Question 2**

If the concentration of Ra-226 in soil remaining in place within the removal area is above the cleanup level then USEPA may initiate or order additional excavation of soil within the removal area.

If the concentration of Ra-226 in soil remaining in place within the removal area is at or below the cleanup level then no further action may be required.

#### **Decision Statements (Directives)**

#### **Directive 1**

Determine whether gamma radiation activity in soil remaining in place within the removal area require removal or confirmation sampling for Ra-226 analysis.

#### **Directive 2**

Determine whether concentrations of Ra-226 in soil remaining in place within the removal area require removal or no further action.

#### STEP 3.

#### **DECISION INPUTS**

#### **Specific Data Required**

- Field data from the established background area to establish a background level of gamma radiation for the radiation survey equipment.
- Field data from measuring gamma radiation activity in soil at the site.
- Definitive analytical data for concentration of Ra-226 in soil at the site.
- Correlated gamma radiation activity to soil cleanup level for Ra-226 determined for the site.
- Soil cleanup level for Ra-226 for the site.
- Global Positioning System data for removal area boundaries, gamma radiation activity measurement locations and soil sampling locations.

#### **Sources for Study Information**

- Navajo Abandoned Uranium Mine Site Screen Report, Section 32 AUM Site, Navajo AUM Eastern Region (Weston 2009)
- Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico (E & E, Removal Assessment Report, Tronox AUM Sections 32 and 33, Eastern Agency, Prewitt, McKinley County, New Mexico, September 2012)
- Site information collected during the removal action including geographical information data and photographs.
- Field data generated during the removal action including real-time radiation survey and soil sampling.
- Definitive analytical data generated during the removal action.
- USEPA Radiation Preliminary Remediation Goals (PRG)

#### **Information Needed to Establish Cleanup Level**

The relationship between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements was evaluated during the removal assessment to determine if gamma radiation activity measurements can be used as a field screening tool to estimate Ra-226 concentrations. Gamma radiation activity can be measured in real-time in the field while Ra-226 concentrations are determined by laboratory analysis which takes months after sampling. The results indicate there is a correlation between surface soil Ra-226 sample results and co-located 1-minute gamma radiation activity measurements and locations with gamma radiation activity measurements below 40,000 cpm using Equipment A1 will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012).

The cleanup level for Ra-226 was based on the sum of the highest background concentration of Ra-226 established for the site during the removal assessment and the USEPA PRG of 1.21 pCi/g (USEPA 2010). The cleanup level for Ra-226 in soil at the site is 2.11 pCi/g.

#### **Confirm that Measurement Methods Exist to Provide Data**

Field instrumentation and measurement methods for radiation monitoring are numerous and have varying detection limits. The same paired Ludlum 44-20 detector and 2221 or 2241 meter will be used in all radiation surveys at the site as practicable. The Ludlum Model 44-20 utilizes a Teledyne Integral Detector assembly containing a 3-inch diameter by 3-inch thick sodium iodide (NaI[T1]) crystal optically coupled to a photomultiplier tube. The detector is compatible with general purpose survey meters, rate meters, and scalers for high-energy gamma detection (approximately 60 kiloelectronvolts [eV] to 2 MeV range) such as the Ludlum Model 2221. The detector provides high sensitivity for surveying typically 2,300 cpm per microRoentgen per hour (based on Cesium-137 gamma) and pulse height discrimination. Quantity measurements are in cpm, which under certain circumstances can be converted to disintegrations per minute or curies.

Laboratory analytical methods that more accurately determine radionuclide concentrations in units of pCi/g in various media are published by USEPA and U.S. Department of Energy (DOE). Ra-226 will be analyzed using the Environmental Measurements Laboratory (EML) Health and Safety Laboratory (HASL) 300 4.5.2.3 Method (DOE, *EML Procedures Manual, HASL-300, 27th Edition, Volume 1, Environmental Measurements Laboratory, 376 Hudson Street, New York, NY 10014-3621, 1990*). This method is applicable to nuclides emitting gamma rays with energies greater than 20keV for germanium detectors Ge(Li) and 50 keV for NaI(T1) detectors and has a minimum detectable activity of 0.5 pCi/g for Ra-226. This method is a modification of USEPA method 901.1 and is the preferred technique for measuring Ra-226 and 228 simultaneously in solid material.

Field instrumentation, field procedures, and laboratory analytical methods used for this project are specified in the SAP.

#### STEP 4.

#### **STUDY BOUNDARIES**

#### **Specify Characteristics that Define the Population Being Studied**

- Gamma radiation activity at 6 inches above the surface of the excavation area.
- Ra-226 concentration in soil (0 to 2 inches bgs) remaining in place within the removal area.

#### **Geographic Boundary of Investigation**

- The site consists two contiguous areas; AUM 32 (365,005 sf) and AUM 33 (153,963 sf) and a non-contiguous transfer Area (267,432 sf). These mine areas are further subdivided for the removal activities into 17 removal areas.
- The vertical investigation boundary for the site will be approximately 4 feet bgs or less based on site conditions.

#### **Temporal Boundary of Investigation**

- The half-life of Ra-226 is 1,600 years. Soil data is not expected to change during the removal action which may take up to 90 days from the last sample collection to final report submittal.
- The removal action was scheduled when the site is accessible and field work is feasible.
- Widespread mining and milling of uranium ore on Navajo tribal lands since the 1940s led to a legacy of AUMs. Data is not available during mine operations at the site or since the mine closed to present. Data collected from the site during this assessment may not represent the highest concentrations historically present in soil at the site due to physical processes such as erosion and migration through the years.
- Data collected during the investigation represent current site conditions and does not consider future development such as soil mixing.
- The cleanup level for Ra-226 is based on PRG which considers long-term health risk.

#### Scale of decision-making

Decisions will apply to each removal area (decision unit) at the site.

#### **Practical Constraints on Data Collection**

#### **Physical Constraints:**

- The sampling areas are in a relatively remote location, which will require additional planning and logistical effort to get resources to the site.
- Weather conditions such as thunderstorms, extreme heat, and high winds may require halting of field work. The wet season may start during the field work schedule; weather conditions such as rain and snow may require field work to be postponed

- until the next dry season.
- Health and safety of staff including lighting conditions and fatigue will limit sampling days to daylight hours and to a maximum of 12 hours per day.
- Presence of heavy equipment during the removal action and site features such as the open shaft at AUM 32 pose unsafe conditions to staff.
- Site features, such as the open shaft, present fall and/or confined space hazards and assessment of these areas is beyond the scope of the current assessment.
- Civil constraints, such as legal site access and unfriendly neighborhoods, and presence of livestock or wild animals will be addressed on site and by direction of the USEPA Task Monitor.

#### **Other Constraints:**

• There is no universal field monitoring instrument capable of providing qualitative, quantitative, and exposure data for all types of radiation. Knowledge of the source is necessary for the selection of the appropriate field measurement instruments.

#### STEP 5.

#### **DECISION RULE**

#### **Statistical Parameter**

The overall gamma radiation activity measurements at each removal area will be compared to the 40,000 cpm field screening level.

The concentration of Ra-226 at each removal area will be compared to the cleanup level.

#### **Cleanup Level**

Gamma radiation activity below 40,000 cpm will likely have mean surface soil concentrations of Ra-226 below the cleanup level of 2.11 pCi/g (E & E 2012). Thus the field screening level is 40,000 cpm.

The cleanup level for Ra-226 in soil at the site was based on the sum of the highest background concentration of Ra-226 established for the site and the USEPA PRG of 1.21 pCi/g for residential soil based on an estimated excess cancer risk of 1 in 10,000 (10<sup>-4</sup>) for Ra-226 and its radioactive decay chain products (Ra-226+D) (USEPA 2010).

#### **Decision Rules**

#### **Question 1**

If the gamma radiation activity measured above larger area of soil remaining in place within a removal area is above 40,000 cpm, then further excavation may be necessary. Otherwise, collect soil samples (0 to 2 inches bgs) within removal area to determine the Ra-226 concentration in soil remaining in place.

#### **Question 2**

If the mean Ra-226 concentration in soil remaining in place within the removal area exceeds the cleanup level then removal or further action may be necessary. Otherwise, no further action may be required.

#### STEP 6.

#### LIMITS ON DECISION ERRORS

#### **Range of the Parameters of Interest**

#### **Activity Rate**

The gamma radiation activity of interest ranges from background to 10 times background. However, the gamma radiation activity from 40,000 cpm to 80,000 cpm is the range most susceptible to decision error.

#### **Concentration in Samples**

Concentrations of interest of Ra-226 in soil samples are from ½ the cleanup level to any value above the cleanup level. Quantitatively precise and accurate determinations of contaminant concentrations that are significantly above (i.e., >10 times) the cleanup level are not necessary. However, concentration from the ½ the cleanup level to twice the cleanup level is the range most susceptible to decision error.

#### **The Null Hypothesis or Baseline Condition**

The parameter of interest (gamma radiation activity and Ra-226 concentration in soil) exceeds the cleanup level.

#### **Alternative Hypothesis**

The parameter of interest (gamma radiation activity and Ra-226 concentration in soil) does not exceed the cleanup level.

DECISION ERRORS			
Decision Error	Deciding that a decision unit is contaminated and requires further action when the decision unit is not contaminated.	Deciding that a decision unit is not contaminated and requires no further action when the decision unit is contaminated.	
True Nature of Decision Error	The activity measurement and sample concentration is either not representative or biased high.	The activity measurement and sample concentration is either not representative or biased low.	
The Consequence of Error	Either further evaluation or a removal action will be initiated. The decision will cost USEPA Region 9 additional resources of time, money, and labor.	The decision could lead to exposure of the community to a substantial and imminent threat to human health.	
Which Decision Error	LESS SEVERE	MORE SEVERE	
Has More Severe Consequences near the Cleanup Level?		The error will endanger human health.	
Error Type	False Acceptance Decisions	False Rejection Decisions	
Based on Consequences	A decision that the decision unit is contaminated when it is not.	A decision that the decision unit is not contaminated when it is.	

#### **DECISION ERRORS**

#### **Definitions**

False Acceptance Decisions = A false acceptance decision error occurs when the null hypothesis is not rejected when it is false. False Rejection Decisions = A false rejection decision error occurs when the null hypothesis is rejected when it is true.

DECISION ERROR LIMITS GOALS			
True Surface Gamma Radiation Activity or Ra-226 Soil Concentration (% of Cleanup Level)	Typical Decision Error Probability Goals (Based on Professional Judgment)	Type of Decision Error	
Less than 50	5%	False Acceptance Decisions	
50 to <100	Gray area <sup>1</sup>	False Acceptance Decisions	
100 to <200	10%²	False Rejection Decisions	
>200	5%	False Rejection Decisions	

The goals in this table are based on professional judgment as relevant to a typical radiation response.

<sup>1</sup> Gray Area is where relatively large decision errors are acceptable.

<sup>2</sup> The large probability for the decision error is expected when the true contaminant concentrations are between 100% and 200% of the cleanup level. Decreasing the probability is possible only by significantly increasing sampling number and quality assurance sampling, since sampling and analytical uncertainties and biases cannot be eliminated.

#### STEP 7.

#### **DESIGN FOR OBTAINING DATA**

#### **Design**

The sampling rationale and design was developed under the direction of the USEPA Task Monitor and START Program Manager, and based on information from other USEPA AUM sites.

#### Gamma Radiation Activity

Gamma radiation activity in soil remaining in place within each removal area will be measured using a paired Ludlum Model 44-20 (3x3) detector and 2241 meter mounted 6 inches from the ground surface. The VIPER system and geographical information system will be used for geospatial information collection and analysis. The surface soil survey will consist of transects spaced 3 to 6 feet apart which will provide 100 percent characterization of the floor of the excavation. The transect width is based on the field of view of the detector which is a diameter of 3 to 6 feet. The surveyor will walk at a pace of 3 feet per second.

#### Ra-226

Soil samples will be collected at 0 to 2 inches bgs from the floor of the excavation footprint and analyzed for Ra-226 by EML HASL 300 4.5.2.3 Method. Three surface soil samples will be collected in each removal area and the concentration compared to the cleanup level of RA-226 of 2.11 pCi/g..

#### **Decision Error Minimization**

#### **Gamma Radiation Scanning Data**

The gamma radiation activity measurement for the entire site is based on 100 percent surface gamma radiation activity scans which collect activity data on a much denser scale and allow for greater confidence in making decisions based on surface contaminant concentrations within a larger area compared to using individual soil sample data points alone. However, decisions in the field using activity data hinge on the relationship and confidence between gamma radiation activity data and Ra-226 concentration data.

The equipment, method, and background area used introduce variation in measurement results. Whenever possible, the same paired Ludlum Model 44-20 (3x3) detector and 2241; measurement method e.g., detector height, pace, specifications; and background area will be used throughout the project. Regular instrument checks will be conducted.

#### **General Requirement for Generating Usable Data**

All activities and documentation related to the project will proceed under a Quality Management Plan. All sampling, analytical, and quality assurance activities will proceed under an USEPA- approved SAP. A record of sampling activities and deviation from the SAP must be documented in a bound field log book. Prior to sample collection, all project sampling personnel will review relevant sampling procedures and relevant quality assurance and control requirements for selected analytical methods.

**B** Site Specific Health and Safety Plan

# **Ecology and Environment, Inc.**

# SITE-SPECIFIC HEALTH AND SAFETY PLAN

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#### 1. INTRODUCTION

#### 1.1 POLICY

It is E & E's policy to ensure the health and safety of its employees, the public, and the environment during the performance of work it conducts. This site-specific health and safety plan (SHASP) establishes the procedures and requirements to ensure the health and safety of E & E employees for the above-named project. E & E's overall safety and health program is described in *Corporate Health and Safety Program* (CHSP). After reading this plan, applicable E & E employees shall read and sign E & E's Site-Specific Health and Safety Plan Acceptance form.

This SHASP has been developed for the sole use of E & E employees and is not intended for use by firms not participating in E & E's training and health and safety programs. Subcontractors are responsible for developing and providing their own safety plans.

This SHASP has been prepared to meet the following applicable regulatory requirements and guidance:

Applicable Regulation/Guidance
29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER)
Other:

#### 1.2 SCOPE OF WORK

Description of Work: The United States Environmental Protection Agency (USEPA) tasked Ecology and Environment, Inc.'s (E & E's) Superfund Technical Assessment and Response Team (START) to support the removal action at the Tronox Abandoned Uranium Mine (AUM) Sections 32 and 33 located in Prewitt, McKinley County, New Mexico in the Casamero Lake Chapter of the Navajo Nation (site). The site is part of the Five-Year Plan for cleaning up the legacy of abandoned uranium mining in the Navajo Nation (USEPA et al. 2008). START will conduct gamma radiation survey and soil sampling to document that gamma radiation activity and Radium-226 (Ra-226) concentration in soil remaining in place at removal areas at the site are below the cleanup level. START developed data quality objectives (DQO) and prepared this Sampling and Analysis Plan (SAP) under the direction of USEPA Federal On-Scene Coordinator (FOSC) Randy Nattis.

Equipment/Supplies: Attachment 1 contains a checklist of equipment and supplies that will be needed for this work.

The following is a description of each numbered task:

Task Number	Task Description
1	Radiation scan/survey of selected soils to determine areas of elevated radiation
2	Collection of soil samples
3	Photo documentation and GPS location.
4	Collection of air samples
5	
6	

#### 1.3 SITE DESCRIPTION

Site Map: See Attachment 2.

Site History/Description (see project work plan for detailed description):

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Tronox AUM: Section 32 (site) is located 1 mile east of County Road 19, in Prewitt, McKinley County, New Mexico (Latitude: 35° 29' 26.7576" N, Longitude: -108° 1' 2.7798" W). The site has an area of 12,102.91 square meters and an undetermined extent of underground workings (Weston 2009). The site is located in an Indian Allotment land which is part of the Casamero Lake Chapter of the Navajo Nation.

The site consists of a mine which was reportedly owned by Cobb Nuclear and was closed due to a fatality (Weston 2009). No other information on historical ownership of the mine and mining operations were available. Site features include an unsecured deep shaft located in the southeastern portion of the site. No residences, public structures, water sources or sensitive environment were found within 0.25 miles of the site. The nearest resident is Lucita Sardo who lives to the west of the mine and had relatives who formerly worked for Cobb Nuclear. The residential property had some materials (tarps and lumber) obtained from the mine and had gamma radiation measurements of approximately 12,000 counts per minute (cpm). Gamma radiation measured at the site ranged from 10,689 cpm to 180,367 cpm. Gamma radiation measured at background locations ranged from 16,630 cpm to 17,128 cpm. No waste piles, other mine features, or visible signs of reclamation were reported.

17,128 cpin. No waste pites, other filme features, or visible signs of fectamation were reported.				
Is the site currently in operation? $\square$ Yes $\boxtimes$ No				
Locations of Contaminants/Wastes: Naturally occurring uranium ore and mine waste is present at the site.				
Types and Characteristics of Contaminants/Wastes:				
Liquid	⊠ Solid	Sludge	☐ Gas/Vapor	
☐ Flammable/Ignitable	☐ Volatile	☐ Corrosive	☐ Acutely Toxic	
☐ Explosive	Reactive	□ Carcinogenic     □	☐ Radioactive	
☐ Medical/Pathogenic	Other:		_	

#### 2. ORGANIZATION AND RESPONSIBILITIES

E & E team personnel shall have on-site responsibilities as described in E & E's standard operating procedure (SOP) for Site Entry Procedures (GENTECH 2.2). The project team, including qualified alternates, is identified below.

Name	Site Role/Responsibility
Craig Tiballi	Project Manager, Field Team Leader
Craig Tiballi	Site Safety Officer, Sample Collection, Radiation Survey
E & E START Field Team	Sample Collection, Radiation Survey, Documentation

#### 3. TRAINING

Prior to work, E & E team personnel shall have received training as indicated below. As applicable, personnel shall have read the project work plan, sampling and analysis plan, and/or quality assurance project plan prior to project work.

Training	Required
40-Hour OSHA HAZWOPER Initial Training and Annual Refresher (29 CFR 1910.120)	X
Annual First Aid/CPR	X
Hazard Communication (29 CFR 1910.1200)	X
40-Hour Radiation Protection Procedures and Investigative Methods	

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Training	Required
8-Hour General Radiation Health and Safety	X
Radiation Refresher	X
DOT and Biannual Refresher	X
Other:	

## 4. MEDICAL SURVEILLANCE

## 4.1 MEDICAL SURVEILLANCE PROGRAM

shall have received, within the past year, an appropriate physical examination and health rating.
E & E's health and safety record (HSR) form will be maintained on site by each E & E employee for the duration of his or her work. E & E employees should inform the site safety officer (SSO) of any allergies, medical conditions, or similar situations that are relevant to the safe conduct of the work to which this SHASP applies.
Is there a concern for radiation at the site? Xes No
If no, go to 5.1.
4.2 RADIATION EXPOSURE
4.2.1 External Dosimetry
Thermoluminescent Dosimeter (TLD) Badges: <u>TLD badges are to be worn by all E &amp; E field personnel at the site and when radiation exposure is anticipated.</u>
Pocket Dosimeters: Electronic or pocket dosimeters will be worn to determine real-time personnel doses if there is a potential for an E & E worker to receive at least 1 milliroentgen (mR) in one day.
Other:
4.2.2 Internal Dosimetry
☐ Whole body count ☐ Bioassay ☐ Other
Requirements:
4.2.3 Radiation Dose
Dose Limits: E & E's radiation dose limits are stated in the CHSP and presented in Table 4-1 below.
Site-Specific Dose Limits: : As a general guidance, if site work will continue for more than one quarter, limit weekly doses to approximately 80 mrem to ensure that quarterly dose limits are not exceeded.

02:HASP 1/08 6 ALARA Policy: <u>Radiation doses to E & E personnel shall be maintained as low as reasonably achievable (ALARA), taking into account the work objective, state of technology available, economics of improvements in dose reduction with respect to overall health and safety, and other societal and socioeconomic considerations.</u>

## Table 4-1 E & E Radiation Dose Limits

Part of Body	Quarterly Limit (rems)	Annual Limit (rems)	Dost Limit Description
Whole body <sup>a</sup>	1	4	Total effective dose equivalent <sup>b</sup>
Any individual organ or tissue other than the lens of the eye <sup>a</sup>	10	40	Sum of deep-dose equivalent <sup>c</sup> and committed dose equivalent <sup>d</sup>
Lens of the eye	3	12	Lens dose equivalent <sup>e</sup>
Skin of whole body or skin of any extremity	10	40	Shallow-dose equivalent <sup>f</sup>

#### Notes:

- a Precedence given to the more limiting dose.
- b The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposure).
- c The dose equivalent at a tissue depth of 1 cm; applies to external whole-body exposure and must be for the part of the body receiving the highest exposure.
- d The dose equivalent to organs or tissues that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.
- e The external exposure of the lens of the eye, taken as the dose equivalent at a tissue depth of 0.3 cm.
- f The external exposure of the skin of the whole body or the skin of an extremity; taken as the dose equivalent at a tissue depth of 0.007 cm averaged over the contiguous 10 square centimeters of skin receiving the highest exposure.

#### 5. SITE CONTROL

#### 5.1 SITE LAYOUT AND WORK ZONES

Site Work Zones: A site map is included as Attachment 2. The work zones will be determined and documented on site. In general, surface gamma activity counts will be used to delineate exclusion zones. Contaminant reduction (Decon) zones will be established at the entry/exits point of the exclusion zone(s). Personnel will need to pass through the Decon area to shed PPE and get checked for radiation contamination when exiting the exclusion zone(s).
Site Access Requirements and Special Considerations: <u>Site access will be arranged by U.S. EPA.</u>
Illumination Requirements: Work will be conducted in daylight hours unless prior approval is obtained and the illumination requirements in 29 CFR 1910.120(m) are satisfied.
Sanitary Facilities (e.g., toilet, shower, potable water): Sanitary facilities will be arranged on site. Bottled water and/or electrolyte beverages will be available.
On-Site Communications: Primary method: verbal; Secondary method: radios/cell phones
Other Site-Control Requirements:

## 5.2 SAFE WORK PRACTICES

Daily Safety Meeting: A daily safety meeting will be conducted for all E & E personnel and documented on the Daily Safety Meeting Record form or in the field logbook. The information and data obtained from applicable site characterization and analysis will be addressed in the safety meetings and also used to update this SHASP, as necessary.

Work Limitations: Work shall be limited to a maximum of 12 hours per day. If 12 consecutive days are worked, at least one day off shall be provided before work is resumed.

Weather Limitations: Work shall not be conducted during electrical storms. Work conducted in other inclement weather (e.g., rain, snow) will be approved by project management and the regional safety coordinator or designee.

Other Work Limitations:	

Buddy System: Field work will be conducted in pairs of team members according to the buddy system.

Line of Sight: Each field team member shall remain in the line of sight and within verbal communication of at least one other team member.

Eating, Drinking, and Smoking: <u>Eating, drinking, smoking, and the use of tobacco products shall be prohibited in the exclusion and contamination reduction areas, at a minimum, and shall only be permitted in designated areas.</u>

Contamination Avoidance: Field personnel shall avoid unnecessary contamination of personnel, equipment, and materials to the extent practicable.

Sample Handling: <u>Protective gloves of a type designated in Section 7 will be worn when containerized samples are handled for labeling, packaging, transportation, and other purposes.</u>

Vermiculite Handling: <u>It is against E&E policy to use vermiculite</u>; therefore, bubble wrap will be used to cushion sample containers for shipment.

Other Safe Work Practices: Cold drinks and a shaded area will be provided to prevent heat stress.

#### 6. HAZARD EVALUATION AND CONTROL

### 6.1 PHYSICAL HAZARD EVALUATION AND CONTROL

Potential physical hazards and their applicable control measures are described in the following table for each task.

Hazard	Task Number	Hazard Control Measures
Biological (flora, fauna, etc.)	1, 2, 3, 4, 5, 6	Potential hazard: feral dogs, prairie dogs (plague carriers), snakes, spiders, poisonous plants
		Establish site-specific procedures for working around identified hazards.
		Other: <u>See attachments</u>
Cold Stress	1, 2, 3, 4	Provide warm break area and adequate breaks.
		■ Provide warm noncaffeinated beverages.
		■ Promote cold stress awareness.
		■ See <i>Cold Stress Prevention and Treatment</i> (attached at the end of this plan if cold stress is a potential hazard).
Compressed Gas Cylinders	N/A	■ Use caution when moving or storing cylinders.
		<ul> <li>A cylinder is a projectile hazard if it is damaged or its neck is broken.</li> </ul>
		Store cylinders upright and secure them by chains or other means.
		■ Other:

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Hazard	Task Number	Hazard Control Measures
Confined Space	N/A	■ Ensure compliance with 29 CFR 1910.146.
-		■ See SOP for Confined Space Entry. Additional documentation is required.
		Other:
Drilling	N/A	<ul> <li>See SOP for Health and Safety on Drilling Rig Operations. Additional documentation may be required.</li> </ul>
		<ul> <li>Landfill caps will not be penetrated without prior discussions with corporate health and safety staff.</li> </ul>
		Other:
Drums and Containers	N/A	■ Ensure compliance with 29 CFR 1910.120(j).
		<ul> <li>Consider unlabeled drums or containers to contain hazardous substances and handle accordingly until the contents are identified.</li> </ul>
		<ul> <li>Inspect drums or containers and assure integrity prior to handling.</li> </ul>
		Move drums or containers only as necessary; use caution and warn nearby personnel of potential hazards.
		<ul> <li>Open, sample, and/or move drums or containers in accordance with established procedures; use approved drum/container-handling equipment.</li> </ul>
		Other:
Electrical	N/A	■ Ensure compliance with 29 CFR 1910 Subparts J and S.
		■ Locate and mark energized lines.
		■ De-energize lines as necessary.
		■ Ground all electrical circuits.
		■ Guard or isolate temporary wiring to prevent accidental contact.
		<ul> <li>Evaluate potential areas of high moisture or standing water and define special electrical needs.</li> </ul>
		Other:
Excavation and Trenching	1, 2, 3, 4	■ Ensure that excavations comply with and personnel are informed of the requirements of 29 CFR 1926 Subpart P.
		■ Ensure that any required sloping or shoring systems are approved as per 29 CFR 1926 Subpart P.
		■ Identify special personal protective equipment (PPE) (see Section 7) and monitoring (see Section 8) needs if personnel are required to enter approved excavated areas or trenches.
		Maintain line of sight between equipment operators and personnel in excavations/trenches. Such personnel are prohibited from working in close proximity to operating machinery.
		Suspend or shut down operations at signs of cave in, excessive water, defective shoring, changing weather, or unacceptable monitoring results.
		Other:
Fire and Explosion	1, 2, 3, 4	Other: Avoid parking vehicles on tall, dry vegetation.
*		■ Inform personnel of the location(s) of potential fire/explosion hazards.
		■ Establish site-specific procedures for working around flammables.
		<ul> <li>Ensure that appropriate fire suppression equipment and systems are available and in good working order.</li> </ul>
		■ Define requirements for intrinsically safe equipment.
		■ Remove ignition sources from flammable atmospheres.
		<ul> <li>Coordinate with local fire-fighting groups regarding potential fire/explosion situations.</li> </ul>
		■ Establish contingency plans and review daily with team members.
		<u></u>

Hazard	Task Number	Hazard Control Measures
Heat Stress	1, 2, 3, 4	■ Provide cool break area and adequate breaks.
		■ Provide cool noncaffeinated beverages.
		■ Promote heat stress awareness.
		■ Use active cooling devices (e.g., cooling vests) where specified.
		■ See <i>Heat Stress Prevention and Treatment</i> (See Attachment 3).
Heavy Equipment Operation	1, 2, 3, 4	■ Define equipment routes, traffic patterns, and site-specific safety measures.
		<ul> <li>Ensure that operators are properly trained and equipment has been properly inspected and maintained. Verify back-up alarms.</li> </ul>
		<ul> <li>Ensure that ground spotters are assigned and informed of proper hand signals and communication protocols.</li> </ul>
		■ Identify special PPE (Section 7) and monitoring (Section 8) needs.
		<ul> <li>Ensure that field personnel do not work in close proximity to operating equipment.</li> </ul>
		■ Ensure that lifting capacities, load limits, etc., are not exceeded.
		Other: Site personnel to wear reflective safety vests
Heights (Scaffolding, Ladders,	N/A	■ Ensure compliance with applicable subparts of 29 CFR 1910.
etc.)		■ Identify special PPE needs (e.g., lanyards, safety nets, etc.)
		Other: Use of fall protection: body harness and lanyard
Noise		■ Establish noise level standards for on-site equipment/operations.
		■ Inform personnel of hearing protection requirements (Section 7).
		■ Define site-specific requirements for noise monitoring (Section 8).
		■ Other:
Overhead Obstructions	N/A	■ Wear hard hat.
		Other:
Power Tools	N/A	■ Ensure compliance with 29 CFR 1910 Subpart P.
		Other:
Sunburn	1, 2, 3, 4	■ Apply sunscreen.
	, , , , ,	■ Wear hats/caps and long sleeves.
		Other:
Utility Lines	N/A	■ Identify/locate existing utilities prior to work.
		Ensure that overhead utility lines are at least 25 feet away from project activities.
		■ Contact utilities to confirm locations, as necessary.
		Other:
Weather Extremes	1, 2, 3, 4	■ Potential hazards:
		■ Establish site-specific contingencies for severe weather situations.
		■ Provide for frequent weather broadcasts.
		Weatherize safety gear, as necessary (e.g., ensure eye wash units cannot freeze, etc.).
		■ Identify special PPE (Section 7) needs.
		■ Discontinue work during severe weather.
Other: Uneven Terrain: Slips, trips & falls	1, 2, 3, 4	<ul> <li>Use three points of contact on steep or rocky slopes and use a backpack to carry tools/supplies so that at least one hand is always free.</li> </ul>
***************************************		■ Watch footing when walking among debris.

Hazard	Task Number	Hazard Control Measures
Other: Burns, Shock, Fire, Noise and heavy lifting hazards from using portable gas-powered Auger	N/A	<ul> <li>Use proper PPE (Level D w/safety goggles, hardhat, work gloves, ear plugs, etc).</li> <li>Wait 20 minutes before refueling hot equipment. Use a funnel and safety gas can to avoid spilling.</li> <li>Always have two persons around when lifting auger</li> </ul>
Open Mine Shaft –	1, 2, 3, 4	■ Bring the mine shaft to the attention of all personnel working on the site.
Open Shafts can extend hundreds of feet to the lower level of a mine. The edge shafts can be concealed by mine debris, dirt, rock, and even water. Once solid beams and frameworks may have been decaying for more many years. In many cases, there may be no support beams at all and the fractured roof or walls of the mine tunnel eventually collapse in response to vibrations and/or the force of gravity. This becomes especially hazardous to personnel conducting gamma surveys, who are often paying more attention to their instruments than what is in front of them.		<ul> <li>Place a visual/physical barrier at least 6 feet outside the edge of the shaft. The barrier may consist of caution tape or construction fencing. Stay away from the edge of the shaft.</li> <li>Keep vehicles as far from the shaft as possible.</li> </ul>
Off-road Driving	1, 2, 3, 4,	■ Drive as slow as possible, and as fast as necessary.
		<ul> <li>Sometimes you cannot drive to your desired destination, so don't push it if conditions are hazardous.</li> </ul>
		■ Stay on the trail.
		■ Walk it first if you cannot see the ground or if conditions are wet.  See attachment for Off-road driving safety.

#### 6.2 CHEMICAL HAZARD EVALUATION AND CONTROL

#### 6.2.1 Chemical Hazard Evaluation

Potential chemical hazards are described by task number in Table 6-1. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

#### 6.2.2 Chemical Hazard Control

An appropriate combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below published exposure levels (see Section 6.2.1).

Applicable Engineering/Administrative Control Measures: Work upwind if possible. Wear PPE appropriate for each task (e.g. Level C in exclusion zone, as defined by elevated surface gamma activity. Avoid soil coming in contact with skin or clothing).

PPE: See Section 7.

#### 6.3 RADIOLOGICAL HAZARD EVALUATION AND CONTROL

### 6.3.1 Radiological Hazard Evaluation

Potential radiological hazards are described below by task number. Hazard Evaluation Sheets for major known contaminants are attached at the end of this plan.

Task Number	Radionuclide	DAC (μCi/ml)	Route(s) of Exposure	Major Radiation(s)	Energy(s) (MeV)	Half-Life
1-6	Uranium, natural (primarily U-238) and daughter radionuclides	marily U-238) and conservative is 3E- ghter 12 for Th-230)		Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 4.5E09 yrs for U-238)
1-6	Radium-226 (a key U- 238 daughter)	3E-10	INH, ING, external radiation exposure	Alpha Gamma	4.8 0.186	1,600 yrs
	Ra-226 daughters	Various		Alpha, beta, gamma	Various	Various
1-6	Radon-222 (direct daughter of Ra-226)	4E-06 (daughters removed) 3E-08 or 0.33 WL (daughters present)	INH	Alpha	5,49	3.8 days
1-6	Thorium, natural (primarily Th-232) and daughter radionuclides	Various (most conservative is 5E- 13 for Th-232)	INH, ING, external radiation exposure	Alpha, beta, gamma, depending on the radionuclide	Various	Various (from seconds to 1.4E10 yrs for Th-232)

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#### 6.3.2 Radiological Hazard Control

Engineering/administrative controls and work practices shall be instituted to reduce and maintain employee exposures to a level at or below the permissible exposure/dose limits (see sections 4.2.3 and 6.3.1). Whenever engineering/administrative controls and work practices are not feasible or effective, any reasonable combination of engineering/administrative controls, work practices, and PPE shall be used to reduce and maintain employee exposures to a level at or below permissible exposure/dose limits.

Applicable Engineering/Administrative Control Measures: <u>Ensure support zone is in an uncontaminated background radiation area</u>. Decrease time in radiation areas; increase distance; increase shielding as needed. Avoid unprotected contact with site materials. Use dust suppression during sampling activities as required. Radiation monitoring equipment will be protected from contamination by placing it in plastic bags (leaving probe areas uncovered). If applicable, ventilate indoor areas (open windows and doors) in order to dissipate any radon buildup.

Radiation Surveying: (This section is intended to apply work-area radiation surveying for worker health and safety purposes. The surveying being conducted for work Task 1 in this safety plan will also suffice to be work-area radiation surveying for worker health and safety purposes.) The work area will be continually surveyed as appropriate to determine radiation exposure rates, areas of elevated radiation, and the location and magnitude of radioactive contamination, in order to ensure and guide worker health and safety. Surveys for gamma exposure will be conducted using a micro R meter (or ion chamber, if the micro R meter goes off-scale [5 mR/hr]) and a survey ratemeter with an attached 3-inch by 3-inch sodium iodide (NaI) (gamma) probe in accordance with established procedures. Off-site background measurements for portable survey instruments will be obtained from locations previously identified by EPA. Radiation levels exceeding approximately 2 times background will indicate radiation contamination and/or radiation areas and will be marked using surveying flags or equivalent. Previous investigations indicate that some areas exceed the action level of 2-3 times background and marking will be required. Workers performing dust generating activites in areas with elevated gamma activity will be required to use Level C PPE, including respirator, tyvek, nitrile gloves, booties, etc. Workers will also don Level C PPE if wind speeds increase to the point that visible dust is present (approx. 20 mph). Although previous data indicate they are not present, a corporate health physicist will be consulted if exposure rates ≥ 2 mR/hr are encountered.

Radiation Contamination Monitoring -Personnel: Personnel will be monitored for radioactive contamination at each work area if gamma activity levels exceeding the site action level (greater than approximately 2-3 times background) are measured. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with E&E's procedure *Radiation Contamination Monitoring of Personnel*. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Radiation contamination monitoring will be performed of protective clothing and respirators as necessary to help with waste disposition decisions and if there is a suspicion of gross contamination that should be controlled before the protective clothing/respirator is removed (to ensure that loose contamination is not transferred to personnel). Otherwise, the protective clothing/respirator can be carefully removed without being monitored and the monitoring will focus on the person in his/her street clothes. Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Radiation Contamination Monitoring - Personal and Work-Related Items, Equipment, and Materials: (This section refers to radiation contamination monitoring of personal and work-related items for health and safety purposes. Examples include monitoring instruments, personal gear, tools, and laptop computers. This does not apply to the free release of non-E & E items.) Radiation contamination monitoring will be performed for personal and work-related items, equipment, and materials as they cross the hotline into the contamination reduction area. The monitoring will be performed using a survey ratemeter with an attached detector such as a pancake GM detector in accordance with established procedures. The relative response of the different detectors to site materials will be determined during initial phases of the work in order to select the best detector for contamination monitoring. Swipe testing will be used for contamination monitoring when direct monitoring is not effective (e.g., small surface areas, nooks and crannies). Swipes will be counted by instruments suitable for the contaminant (typically, fixed-geometry, thin-window counters for uranium and its daughters). Contamination results exceeding approximately 2 to 3 times background indicate contamination and that decontamination or disposal as a contaminated waste must be performed (see Section 9).

Air Monitoring and Sampling: E&E personnel will collect air samples upwind, downwind and in the work zone while dust generating activities are occurring in contaminated areas. This sampling is primarily to assess and document

whether contaminated fugitive dust is being generated by site activities but sample results will also be used for health and safety. When sample data for a work zone are not available or if data documents airborne contamination that requires use of respiratory protection, personnel will don Level C PPE during dust generating activities that are performed in areas with elevated gamma activity. The U.S. Nuclear Regulatory Commission derived air concentrations (DACs, 10 Code of Federal Regulations Part 20 Appendix B Table 1) for the radioisotopes thorium-232 (5E-13 microCuries per milliliter [µCi/mL]) and Ra-226 (3E-10 µCi/mL) will be used as the permissible exposure levels. The DAC for thorium-232 (Th-232) was selected over the DACs for other thorium species because it is the most conservative. The Ra-226 DAC was selected over the DACs for its shorter-lived daughter products (such as radon-222 [Rn-222]) because it is more conservative.

The activity concentration value will be measured on the collected air filters each day, several hours after collection. The alpha activity concentration will initially be compared to the Th-232 DAC to identify whether additional engineering controls are required (e.g. respirators). The alpha activity concentration for each air filter will then be measured again approximately 24 hours and 72 hours after collection to identify whether the alpha activity counts are declining, which is expected due to decay. If significant decay is demonstrated, then the source of radioisotopes are not a thorium species, which have extremely long half-lives (billions of years). Instead, the likely source radioisotopes are the shorter-lived uranium-decay series daughter products such as Rn-222. Previous air sampling results for the USEPA Skyline Mine AUM Removal Project located approximately 50 miles northwest in a similar topographic and geologic setting indicate that worker exposure at concentrations exceeding the DAC does not occur when gamma activity is less than approximately 3-4 times background. During the Skyline project in March to October 2011, daily air samples were collected from locations upwind, downwind and in the work zone while relatively heavy dust generating activities were occurring. The START analyzed the samples using an alpha detector. Calculations based on the known volume of air and the measured alpha activity indicated detected concentrations of airborne radioactive particulates were consistently below the DAC for Thorium 232 of 5 x 10<sup>-13</sup>. This is the most conservative DAC of expected radioactive site contaminants. Additionally, the DAC is based on the dose a worker would receive in a 2000 hour work year. Work on this and all other radiation sites for project team members is not expected to exceed 240 hours per year. The limited exposure period, in conjunction with the documented air sampling results will be used to documents that workers are not being exposed above the permissible levels. Radon levels are not considered a health risk as all activities will occur outdoors in open areas.

PPE: See Section 7.

# TABLE 6-1 CHEMICAL HAZARD EVALUATION

Task		Exposure Limits (TWA)		Dermal Route(s) of		Odor	FID	/PID		
Number	Compound	PEL	REL	TLV	Hazard (Y/N)	1azara Evnosuro	Acute Symptoms	Threshold/ Description	Relative Response	Ioniz. Poten. (eV)
1-4	Uranium (insoluble compounds)	0.25 mg/m3	0.2 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA
1-4	Uranium (soluble compounds)	0.05 mg/m3	0.05 mg/m3	0.2 mg/m3	N	inhalation, ingestion, skin and/or eye contact	Lacrimation (discharge of tears), conjunctivitis; shortness breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] [Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).]	odorless	NA	NA

Note: Use an asterisk (\*) to indicate known or suspected carcinogens.

#### 7. LEVEL OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT

#### 7.1 LEVEL OF PROTECTION

The following levels of protection (LOPs) have been selected for each work task based on an evaluation of the potential or known hazards, the routes of potential hazard, and the performance specifications of the PPE. On-site monitoring results and other information obtained from on-site activities will be used to modify these LOPs and the PPE, as necessary, to ensure sufficient personnel protection. The authorized LOP and PPE shall only be changed with the approval of the regional safety coordinator or designee. Level A is not included below because Level A activities, which are performed infrequently, will require special planning and addenda to this SHASP.

Task Number	В	C	D	Modifications Allowed
1			X	
2			X	
3		(X)	X	Based on experiences with air sampling for gross alpha/beta on other uranium mine sites in New Mexico (e.g., NECR and Skyline), air sampling results from high dust-generating activities such as vehicular traffic, soil excavation and loading, and grading were still orders of magnitude below the most conservative DAC. Dust generating activities will involve RAT work and soil sampling. If dust caused by high winds should impact work activities, it is likely that it would involve nuisance dust. Therefore, worker protection decisions can be managed visually.
4			X	

Note: Use "X" for initial levels of protection. Use "(X)" to indicate levels of protection that may be used as site conditions warrant.

## 7.2 PERSONAL PROTECTIVE EQUIPMENT

The PPE selected for each task is indicated below. E & E's PPE program complies with 29 CFR 1910.120 and 29 CFR 1910 Subpart I and is described in detail in the CHSP. Refer to 29 CFR 1910 for the minimum PPE required for each LOP.

	Task Number/LOP					
PPE	1/D	2/D	3/D	4/D		
Full-face APR			(X)			
PAPR						
Cartridges:						
P100			(X)			
GMC-P100						
GME-P100			(X)			
Other:						
Positive-pressure, full-face SCBA						
Spare air tanks (Grade D air)						
Positive-pressure, full-face, supplied-air system						

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	Task Number/LOP					
PPE	1/D	2/D	3/D	4/D		
Cascade system (Grade D air)						
Manifold system						
5-Minute escape mask						
Safety glasses			X			
Monogoggles						
Coveralls/clothing			(X)			
Protective clothing:						
Tyvek		(X)	(X)	(X)		
Saranex						
Other:						
Splash apron						
Inner gloves:						
Cotton						
Nitrile		(X)	(X)	(X)		
Latex						
Other:						
Outer gloves:						
Viton						
Rubber						
Neoprene						
Nitrile		X	X	X		
Other:						
Work gloves		(X)	(X)	(X)		
Safety boots (as per ANSI Z41)	X	X	X	X	X	X
Neoprene safety boots (as per ANSI Z41)						
Boot covers (type: poly)		(X)	(X)	(X)	(X)	
Hearing protection (type:)						
Hard hat						
Face shield						
Other:						
Other:						

#### 8. HEALTH AND SAFETY MONITORING

Health and safety monitoring will be conducted to ensure proper selection of engineering/administrative controls, work practices, and/or PPE so that employees are not exposed to hazardous substances at levels that exceed permissible exposure/dose limits or published exposure levels. Health and safety monitoring will be conducted using the instruments, frequency, and action levels described in Table 8-1. Health and safety monitoring instruments shall have been appropriately calibrated and/or performance-checked prior to use.

#### 9. DECONTAMINATION PROCEDURES

All equipment, materials, and personnel will be evaluated for contamination upon leaving the exclusion area. Equipment and materials will be decontaminated and/or disposed and personnel will be decontaminated, as necessary. Decontamination will be performed at each sample area if radiation levels exceeding the site action level (greater than 2-3 times background) are recorded. Specific procedures are described below.

Equipment/Material Decontamination Procedures (specified by work plan): Every effort will be made to prevent radiation survey instruments from contacting contaminated materials. When appropriate, instruments, probe handles (not probe faces), and other personal and work-related items will be covered in plastic to prevent surficial contamination. Nondisposable items that are radioactively contaminated as determined by direct and indirect monitoring (Sections 6.3.2 and 8) will be decontaminated using controlled dry or damp methods (e.g., Radiacwash towelettes or wet wipes) and remonitored when dry to ensure the contamination was removed. Disposable items that are contaminated will be directed to the proper waste stream.

Ventilation: All decontamination procedures will be conducted in a well-ventilated area.

Personnel Decontamination Procedures: Personnel radiation contamination monitoring will be performed in accordance with Sections 6.3.2 and 8. Disposable protective clothing will be directed to the proper waste stream and respirators will be directed to a respirator washing station. Contaminated areas on the skin or body will be decontaminated using controlled dry or damp methods and re-monitored when dry to ensure the contamination was removed. Significant or stubborn contamination will be decontaminated under the guidance of a health physicist. Contaminated areas on personal apparel will be decontaminated if possible; otherwise, the apparel will be directed to the proper waste stream. "Hot spot" decon is recommended to minimize the volume of waste generated. Practices such as cutting the hot spot out of the protective clothing or using duct tape to remove the contaminant will be employed as appropriate.

PPE Requirements for Personnel Performing Decontamination: <u>Safety glasses and nitrile gloves</u>

Personnel Decontamination in General: <u>Following appropriate decontamination procedures, all field personnel will wash</u> their hands and face with soap and potable water. Personnel should shower at the end of each work shift.

Disposition of Disposable PPE: Disposable PPE must be rendered unusable and disposed as indicated in the work plan.

Disposition of Decontamination Wastes (e.g., dry wastes, decontamination fluids, etc.): Disposed of off-site by qualified disposal contractor if greater than 30 pCi/g (approximately 100 Kcpm gamma activity). Disposed of as municipal waste if less than 2-3 times background.

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## TABLE 8-1

## HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels <sup>a</sup>		
□ PID				Continuous	Unknown Vapors	Contaminant-Specific	
(e.g., RAE mini RAE)  □ FID					Background to 1 ppm above background: Level D		
(e.g., OVA 128-)					1 to 5 ppm above background: Level C		
□ TVA 1000					5 to 500 ppm above background: Level B		
					>500 ppm above background: Level A		
Oxygen					Oxygen	Explosivity	
Meter/Explosimeter					<19.5% or >22.0%: Evacuate area; eliminate ignition sources; reassess conditions.  19.5 to 22.0%: Continue work in accor-	<10% LEL: Continue work in accordance with action levels for other instruments; monitor continuously for combustible atmospheres.	
					dance with action levels for other instruments.	>10% LEL: Evacuate area; eliminate ignition sources; reassess conditions.	
Radiation Alert Monitor					<0.1 mR/hr: Continue work in accordance w	ith action levels for other instruments.	
(Rad-mini or RAM-4)					≥0.1 mR/hr: Evacuate area; reassess work pl	an and contact radiation safety specialist.	
Mini-Ram Particulate					General/Unknown	Contaminant-Specific	
Monitor					Evaluate health and safety measures when dust levels exceed 2.5 milligrams per cubic meter.		
HCN/H <sub>2</sub> S (Monitox)					≥4 ppm: Leave area and consult with SSO.		
Draeger Colorimetric Tubes					Tube Action	Level Action	
Air Monitor/Sampler					Action Level	Action	
Туре:							
Sampling medium:							

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## TABLE 8-1

## HEALTH AND SAFETY MONITORING

Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels <sup>a</sup>
Personal Sampling Pump Type: Sampling medium:					Action Level Action
Micro R Meter (Ludlum 19) with Rapid Assessment Tool (RAT)		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	<2 mR/hr: Continue work in accordance with action levels for other instruments.  2 to 5 mR/hr: In conjunction with a radiation safety specialist, continue work and perform stay-time calculations to ensure compliance with dose limits and ALARA policy.
Ion Chamber		External gamma exposure	Work area	As necessary to characterize work area. Continuous when used.	See micro R meter action levels above.

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## TABLE 8-1

## HEALTH AND SAFETY MONITORING

	T		-	T	T		
Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency		Action Levels <sup>a</sup>	
Radiation Survey	1, 2, 3, 4	Gamma radiation	Work area	As necessary to	Detector	Action Level	Action
Ratemeter/Scaler with				characterize work area.	3" x 3" NaI (gamma)	> 2 to 3 x Bkg	Consider radiation levels to be elevated.
External Detector(s)				Continuous when used.			cicvated.
(Ludlum 2241, pancake GM detector)				when used.			
2		Radionuclides	Work area (sensitive measurement of hot spots and contaminated areas) as necessary	As necessary to characterize work area	GM, ZnS, or gas-flow proportional and/or swipe testing	General: > 2 to 3x Bkg.	. Consider radioactive and/or contaminated.
		Radionuclices	Personnel and personal equipment/mate rial contamination monitoring <sup>b</sup>	As necessary as personnel and personal equipment/ materials cross hotline	GM detector and/or swipe testing	> 2 to 3x Bkg	Consider radioactive and/or contaminated
Noise Dosimeter					<85 decibels as measured exposure will be sustained.		rk (dBa): Use hearing protection if
(Sound Level Meter)					>85 dBA: Use hearing pr	<u> </u>	
						d consult with safety person	nel.
Other: Pocket Dosimeter	1, 2, 3, 4	Gamma radiation, Radionuclices	Personnel and personal equipment/mate rial contamination monitoring <sup>b</sup>	As necessary as personnel and personal equipment/ materials cross hotline		mRem in one day II s	n conjunction with a radiation safety pecialist, continue work and perform tay-time calculations to ensure compliance with dose limits and ALARA policy.
Other:							

TABLE 8-1					
			HEAL	TH AND SAFETY	MONITORING
Instrument	Task Number	Contaminant(s)	Monitoring Location	Monitoring Frequency	Action Levels <sup>a</sup>

a Unless stated otherwise, airborne contaminant concentrations are measured as a time-weighted average in the worker's breathing zone. Acceptable concentrations for known airborne contaminants will be determined based on OSHA/NIOSH/ACGIH and/or NRC exposure limits. As a guideline, 1/2 the PEL/REL/TLV, whichever is lower should be used.

### 10. EMERGENCY RESPONSE

This section contains additional information pertaining to on-site emergency response and does not duplicate pertinent emergency response information contained in earlier sections of this plan (e.g., site layout, monitoring equipment, etc.). Emergency response procedures will be rehearsed regularly, as applicable, during project activities.

#### 10.1 EMERGENCY RESPONSIBILITIES

All Personnel: All personnel shall be alert to the possibility of an on-site emergency; report potential or actual emergency situations to the team leader and SSO; and notify appropriate emergency resources, as necessary.

Team Leader: The team leader will ensure that applicable incidents are reported to appropriate E & E and client project personnel and government agencies.

SSO: The SSO will determine the emergency actions to be performed by E & E personnel and will direct these actions. The SSO will recommend health/safety and protective measures appropriate to the emergency.

Other

## 10.2 LOCAL AND SITE RESOURCES (including phone numbers)

Ambulance: 911 (Gallup Metro Dispatch)

Hospital: Cibola General Hospital, 1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

Directions to Hospital (map attached at the end of this plan): <u>Head SW on Co Rd 19. Turn left onto NM-122E/Frontage</u> Road for 18 miles. Continue onto W Santa Fe Ave for 1.4 miles. Turn left onto 1<sup>st</sup> St for 0.9 miles. Slight right onto W Roosevelt Ave. Hospital will be on the left in 0.7 miles.

Poison Control: 800-222-1222

Police Department: 911 (Gallup Metro Dispatch)

Fire Department: 911 (Gallup Metro Dispatch)

Client Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

Site Contact: Randy Nattis, EPA FOSC; Phone (415) 940-1108

On-Site Telephone Number: NA

Cellular Telephone Number: NA

Radios Available: Yes

Other:

## 10.3 E & E EMERGENCY CONTACTS

E & E Emergency Operations Center (24 Hours): 716/684-8060

Corporate Health and Safety Director, Dr. Paul Jonmaire: 716/684-8060 (office)

716/655-1260 (home)

Regional Office Contact: Cindy McLeod, START Program Manager 510/893-6700 (office)

415/238-3379 (cell)

510/654-6250 (home)

Other: START Oakland Office 510/893/6700 (office)

a. E & E Emergency Response Center: 716/684-8060

b. Corporate Health and Safety Director, Dr. Paul Jonmaire: 716/684-8060 (office)

716/655-1260 (home)

c. Assistant Corporate Safety Director, Tom Siener, CIH: 716/684-8060 (office)

716/662-4740 (home) 716/597-5868 (Cell)

#### 10.4 OTHER EMERGENCY RESPONSE PROCEDURES

On-Site Evacuation Signal/Alarm (must be audible and perceptible above ambient noise and light levels): <u>Three long blasts on car horn or air horn.</u>

On-Site Assembly Area: An upwind location to be determined at the first Daily Safety Meeting

Emergency Egress Route to Get Off Site: To be determined at the first Daily Safety Meeting

Off-Site Assembly Area: To be determined at the first Daily Safety Meeting

Preferred Means of Reporting Emergencies: Report to FOSC Nattis and Call 911

Site Security and Control: <u>In an emergency situation</u>, <u>personnel will attempt to secure the affected area and control site</u> access.

Emergency Decontamination Procedures: Non-life-threatening: protective clothing will be removed and affected persons will be monitored for radiation, especially the hands and feet, to the extent practicable. Life-threatening: critically injured personnel will be wrapped in a blanket or plastic sheeting to prevent the spread of contamination. Plastic sheeting should be used in transport vehicle to prevent the spread of contamination. If time permits and necessary medical treatment will not be delayed, removal of protective clothing and monitoring for radiation can be performed. Emergency decontamination for other chemical hazards will include PPE removal and rinsing with water if applicable.

PPE: <u>Personnel will don appropriate PPE when responding to an emergency situation.</u> The SSO and Section 7 of this plan will provide guidance regarding appropriate PPE.

Emergency Equipment <u>Appropriate emergency equipment is listed in Attachment 1</u>. <u>Adequate supplies of this equipment shall be maintained in the support area or other approved work location.</u>

Incident Reporting Procedures: <u>The SSO will notify the Regional Safety Coordinator and the EPA FOSC.</u> Affected personnel will complete an Incident/Exposure Report within 24 hours and submit it to the Corporate Health and Safety <u>Director.</u>

## ATTACHMENT 1

## EQUIPMENT/SUPPLIES CHECKLIST

	No.
INSTRUMENTATION	
FID	
Thermal desorber	
O <sub>2</sub> /explosimeter w/cal. Kit	
Photovac tip	
PID (probe:eV)	
Magnetometer	
Pipe locator	
Weather station	
Draeger tube kit (tubes:)	
Brunton compass	
Real-time cyanide monitor	
Real-time H <sub>2</sub> S monitor	
Heat stress monitor	
Noise equipment	
Personal sampling pumps and supplies	
MiniRam dust monitor	
Mercury monitor	
Spare batteries (type: D)	
RADIATION EQUIPMENT/SUPPLIES	
Documentation forms	X
Portable ratemeter	X
Scaler/ratemeter	X
1" NaI gamma probe	
3" NaI gamma probe	X
ZnS alpha probe	
GM pancake probe	X
Tungsten-shielded GM probe	
Micro R meter	
Ion chamber	
Alert monitor	
Pocket dosimeter	X
Dosimeter charger	X
Radiation warning tape	

	No.
Radiation decon supplies	X
Spare batteries (type:D - rate meters and Micro R meter; AAA - pocket dosimeters	X
SAMPLING EQUIPMENT	Г
4oz. bottles	X
Half-gallon bottles	
VOA bottles	
String	
Hand bailers	
Thieving rods with bulbs	
Spoons	X
Knives	
Filter paper	
Bottle labels	X
Ziplock Bags 1 gallon	X
Ziplock Bags 2 gallon	
MISCELLANEOUS	
GPS	X
Surveyor's tape	X
100' Fiberglass tape	
300' Nylon rope	
Nylon string	X
Surveying flags	X
Camera	X
Film	
Bung wrench	
Soil auger	X
Pick	
Shovel	X
Catalytic heater	
Propane gas	
Banner tape	
Surveying meter stick	
Chaining pins and ring	
Logbooks ( large,X small)	X

	No.
Required MSDSs	
Intrinsically safe flashlight	
Potable water	X
Gatorade or equivalent	X
Tables	
Chairs	
Weather radio	
Two-way radios	
Binoculars	
Megaphone	
Cooling vest	
EMERGENCY EQUIPMENT	
First aid kit	X
Stretcher	
Portable eye wash	
Blood pressure monitor	
Fire blanket	
Fire extinguisher	
Thermometer (medical)	
Spill kit	
DECONTAMINATION EQUIPMENT	
Wash tubs	
Buckets	
Scrub brushes	
Pressurized sprayer	
Spray bottle	X
Detergent (type: : RadiacWash or equivalent )	X
Solvent (type:)	
Plastic sheeting	
Tarps and poles	
Trash bags	X
Trash cans	
Masking tape	X
Duct tape	X

	No.
Paper towels	X
Face mask	
Face mask sanitizer	
Step ladders	
Distilled water	X
Deionized water	
SHIPPING EQUIPMENT	
Coolers	X
Paint cans with lids, 7 clips each	
Vermiculite	
Shipping labels	X
DOT labels:	
"Up"	
"Danger"	
"Inside Container Complies"	
Hazard Group	
Strapping tape	X
Baggies	X
Custody seals	X
Chain-of-custody forms	X
Express shipment forms	X
Clear packing tape	X
Permanent markers	X

## DAILY SAFETY MEETING RECORD

## INITIAL PROJECT SAFETY CHECKLIST

- 1. Emergency information reviewed? \_\_\_\_ and made familiar to all team members?
- 2. Route to nearest hospital driven? \_\_\_ and its location known to all team members?
- 3. Health and safety plan readily available and its location known to all team members?
- 4. E & E Drilling SOP on site? \_\_\_ and available for team member review?

#### **ATTENDEES**

Meeting shall be attended by all personnel who will be working within the exclusion area. Daily informal update meetings will be held prior to work and when site tasks and/or conditions change.

Name (Printed)	Name (Signature)	Date	Representing (Company/Agency)
	(2-6		( - z - z - z - z - z - z - z - z - z -
Meeting Conducted By:			

## Search the Pocket Guide

SEARCH

Enter search terms separated by spaces.

Ur	anium (s	soluble compounds, as U)		
Synonyms & Trade Names Synonyn	ns vary depe	nding upon the specific soluble uranium compound.		
CAS No.	RTECS No.	DOT ID & Guide		
	Conversion	IDLH Ca [10 mg/m³ (as U)] See: uranium (/niosh/idlh/uranium.html)		
Exposure Limits NIOSH REL: Ca TWA 0.05 mg/ Appendix A (nengapdxa.html) OSHA PEL: TWA 0.05 mg/m³	m³ <u>See</u>	Measurement Methods None available See: NMAM (/niosh/docs/2003-154/) or OSHA Methods (http://www.osha.gov/dts/sltc/methods/index.html)		
Physical Description Appearance	and odor var	y depending upon the specific soluble uranium compound.		
Properties vary depending upon the specific soluble uranium compound.				
Incompatibilities & Reactivities Uranyl nitrate: combustibles Uranium hexafluoride: water				
Exposure Routes inhalation, ingestion, skin and/or eye contact				

**Symptoms** lacrimation (discharge of tears), conjunctivitis; short breath, cough, chest rales; nausea, vomiting; skin burns; red blood cell, casts in urine; proteinuria; high blood urea nitrogen; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs respiratory system, blood, liver, kidneys, lymphatic system, skin, bone marrow

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection

codes (protect.html) )

**Skin:** Prevent skin contact **Eyes:** Prevent eye contact

**Wash skin:** When contaminated/Daily **Remove:** When wet or contaminated

**Change:** Daily

**Provide:** Eyewash (UF<sub>6</sub>), Quick drench

First Aid (See procedures (firstaid.html))

**Eye:** Irrigate immediately **Skin:** Water flush immediately **Breathing:** Respiratory support

**Swallow:** Medical attention immediately

**Respirator Recommendations** 

## **NIOSH**

## At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

## **Escape (Halides):**

(APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having an N100, R100, or P100 filter.

<u>Click here (pgintrod.html#nrp)</u> for information on selection of N, R, or P filters.

Any appropriate escape-type, self-contained breathing apparatus

## **Escape (Non-halides):**

(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter.

<u>Click here (pgintrod.html#nrp)</u> for information on selection of N, R, or P filters.

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: <u>INTRODUCTION</u> (/niosh/npg/pgintrod.html) See MEDICAL TESTS: <u>0239</u> (/niosh/docs/2005-110/nmed0239.html)

Page last reviewed: April 4, 2011 Page last updated: November 18, 2010

Content source: National Institute for Occupational Safety and Health (NIOSH) Education and Information Division

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## Search the Pocket Guide

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## Uranium (insoluble compounds, as U)

Synonyms & Trade Names Uranium metal: Uranium I

Synonyms of other insoluble uranium compounds vary depending upon the specific compound.

CAS No. 7440-61-1 (metal)	RTECS No. YR3490000 (metal) (/niosh- rtecs/YR3540D0.html)	DOT ID & Guide 2979 162 (http://wwwapps.tc.gc.ca/saf-sec-sur/3/erg-gmu/erg/guidepage.aspx?guide=162) (metal, pyrophoric)
Formula U (metal)	Conversion	толн Ca [10 mg/m³ (as U)] See: <u>7440611 (/niosh/idlh/7440611.html)</u>
Exposure Limits	/ - <b>am</b> a a / - a	Measurement Methods None available

NIOSH REL: Ca TWA 0.2 mg/m<sup>3</sup> ST 0.6 mg/m<sup>3</sup> See

Appendix A (nengapdxa.html)

OSHA PEL † (nengapdxg.html): TWA 0.25 mg/m<sup>3</sup>

See: NMAM (/niosh/docs/2003-154/) or OSHA

Methods 2

(http://www.osha.gov/dts/sltc/methods/index.html)

Physical Description Metal: Silver-white, malleable, ductile, lustrous solid. [Note: Weakly radioactive.]

<b>MW</b> : 238.0	<b>вр:</b> 6895° F	MLT: 2097°F	sol: Insoluble	VP: 0 mmHg (approx)	IP: NA
<b>Sp.Gr:</b> 19.05 (metal)	Fl.P: NA	uel: NA	LEL: NA		<b>MEC:</b> 60 g/m <sup>3</sup>

Metal: Combustible Solid, especially turnings and powder.

Incompatibilities & Reactivities Carbon dioxide, carbon tetrachloride, nitric acid, fluorine [Note: Complete coverage of uranium metal scrap with oil is essential for prevention of fire.]

Exposure Routes inhalation, ingestion, skin and/or eye contact

Symptoms dermatitis; kidney damage; blood changes; [potential occupational carcinogen]; in animals: lung, lymph node damage; [potential occupational carcinogen] Potential for cancer is a result of alpha-emitting properties & radioactive decay products (e.g., radon).

Target Organs Skin, kidneys, bone marrow, lymphatic system

Cancer Site [lung cancer]

Personal Protection/Sanitation (See protection codes

(protect.html))

**Skin:** Prevent skin contact **Eyes:** Prevent eye contact

**Wash skin:** When contaminated/Daily

First Aid (See procedures (firstaid.html)

**Eve:** Irrigate immediately **Skin:** Soap wash promptly **Breathing:** Respiratory support

**Swallow:** Medical attention immediately

Remove: When wet or contaminated

**Change:** Daily **Provide:** Eyewash

**Respirator Recommendations** 

## **NIOSH**

## At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration:

(APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode

(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus

## **Escape:**

(APF = 50) Any air-purifying, full-facepiece respirator with an N100, R100, or P100 filter. Click here (pgintrod.html#nrp) for information on selection of N, R, or P filters.

Any appropriate escape-type, self-contained breathing apparatus

Important additional information about respirator selection (pgintrod.html#mustread)

See also: <u>INTRODUCTION</u> (/niosh/npg/pgintrod.html) See ICSC CARD: <u>1251</u> (/niosh/ipcsneng/neng1251.html) See MEDICAL TESTS: 0239 (/niosh/docs/2005-110/nmed0239.html)

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<< Back to Occupational Safety and Health Guidelines

## Occupational Safety and Health Guideline for Uranium and Insoluble Compounds

#### DISCLAIMER:

These guidelines were developed under contract using generally accepted secondary sources. The protocol used by the contractor for surveying these data sources was developed by the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the Department of Energy (DOE). The information contained in these guidelines is intended for reference purposes only. None of the agencies have conducted a comprehensive check of the information and data contained in these sources. It provides a summary of information about chemicals that workers may be exposed to in their workplaces. The secondary sources used for supplements III and IV were published before 1992 and 1993, respectively, and for the remainder of the guidelines the secondary sources used were published before September 1996. This information may be superseded by new developments in the field of industrial hygiene. Therefore readers are advised to determine whether new information is available.

Introduction | Applicability | Recognition | Evaluation | Controls | References | Bibliography | Reference Table

#### Introduction

This guideline summarizes pertinent information about uranium and insoluble uranium compounds (measured as uranium) for workers and employers as well as for physicians, industrial hygienists, and other occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professionals who may need such information to conduct effective occupational safety and health professional safet programs. Recommendations may be superseded by new developments in these fields; readers are therefore advised to regard these recommendations as general guidelines and to determine periodically whether new information is available.

#### **Applicability**

This guideline applies to metallic uranium and all insoluble uranium compounds; examples of such compounds include triuranium octaoxide, uranium dioxide, uranium hydride, uranium tetrafluoride, and uranium trioxide. The physical and chemical properties of uranium and of some insoluble uranium compounds are presented below for illustrative purposes

### Recognition

Metallic uranium

#### SUBSTANCE IDENTIFICATION

- \* Formula
- U \* Structure

(For Structure, see paper copy)

- Synonyms
- U; Uranium metal, pyrophoric; uranium
- \* Identifiers
  - CAS 7440-61-1.
  - 2. RTECS YR3490000.
  - DOT UN: 2979 65 (for the pyrophoric forms of the metal).
  - DOT labels: Radioactive and Flammable Solid.

Elemental uranium is a heavy, malleable, silvery white, lustrous, radioactive metal that is pyrophoric when finely divided. When uranium is obtained by reduction, it take the form of a black powder. In its natural state, uranium has three isotopes: (234)U, (235)U, and (238)U. U-238 has a half life of 4,510,000,000 years

#### CHEMICAL AND PHYSICAL PROPERTIES

- \* Physical data
  - Atomic number: 92.
  - Atomic weight: 238.03.

  - Rolling point (760 torr): 3818 degrees C (6904 degrees F).

    Specific gravity (water = 1): 19.05 + 0.02 at 20 degrees C (68 degrees F).

  - Vapor density: Not applicable. Melting point: 1132.3 degrees C (2070 degrees F). 6.
  - Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
  - Solubility: Insoluble in water, alcohol, and alkalies; soluble in acids.

9. Evaporation rate: Not applicable.

Triuranium Octaoxide

#### SUBSTANCE IDENTIFICATION

\* Formula

U(3)O(8)

 \* Structure (For Structure, see paper copy)

\* Synonyms Uranium oxide, pitchblende, nasturan, uraninite.

- \* Identifiers
  - 1. CAS 1317-99-3.
  - RTECS YR3400000.
  - 3. Specific DOT number: None.
  - 4. Specific DOT label: None.
- \* Appearance and odor

Triuranium octaoxide is an olive green to black, odorless solid.

#### **CHEMICAL AND PHYSICAL PROPERTIES**

- \* Physical data
  - Molecular weight: 842.1.
  - Boiling point: Not applicable.
  - Specific gravity (water = 1): 8.30 at 20 degrees C (68 degrees F) Vapor density: Not applicable.

  - Melting point: 1300 degrees C (2372 degrees F) (decomposes to uranium dioxide)
  - Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
  - Solubility: Insoluble in water; soluble in nitric and sulfuric acids.
  - 8. Evaporation rate: Not applicable.

Uranium dioxide

#### SUBSTANCE IDENTIFICATION

\* Formula

UO(2)

\* Structure

(For Structure, see paper copy)

\* Synonyms

Uranous oxide, black uranium oxide, uranium oxide, uranic oxide, urania, yellow cake.

- \* Identifiers
  - 1. CAS 1344-57-6.
  - 2. RTECS: None.
  - 3. Specific DOT number: None.
  - 4. Specific DOT label: None.
- \* Appearance and odor

Uranium dioxide is a pyrophoric, black, crystalline solid. It occurs naturally in various minerals including uraninite, pitchblende, and tyuyamunite. The latter is the most important mineral commercially.

#### **CHEMICAL AND PHYSICAL PROPERTIES**

- \* Physical data
  - Molecular weight: 270.03.
  - Boiling point: Data not available.
  - Specific gravity (water = 1): 10.96 at 20 degrees C (68 degrees F)

  - 4. Vapor density: Not applicable.
    5. Melting point: 2858-2898 degrees C (5176-5248 degrees F).
  - Vapor pressure: Not applicable. 6.
  - Solubility: Insoluble in water; soluble in concentrated sulfuric acid and nitric acid.
- 8. Evaporation rate: Not applicable.

Uranium hydride

#### SUBSTANCE IDENTIFICATION

- \* Formula
- UH(3)
- \* Structure

(For Structure, see paper copy)

- \* Synonyms
- Uranium trihydride.
- \* Identifiers
- 1. CAS 13598-56-6.
- 2. RTECS: None.
- 3. Specific DOT number: None.
- 4. Specific DOT label: None.
- \* Appearance and odor

Uranium hydride is a brownish-black or brownish-gray, pyrophoric powder.

#### **CHEMICAL AND PHYSICAL PROPERTIES**

- \* Physical data
  - Molecular weight: 241.05

  - Boiling point (760 torr): Not applicable. Specific gravity (water = 1): 10.95 at 20 degrees C (68 degrees F).
  - Vapor density: Not applicable.
  - Melting point: Decomposes.
  - Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
  - Solubility: Insoluble in water, alcohol, acetone, or liquid ammonia; slightly soluble in dilute hydrogen chloride; decomposes in nitric acid.
  - Evaporation rate: Not applicable.

Uranium tetrafluoride

#### SUBSTANCE IDENTIFICATION

\* Formula

UF(4)

\* Structure

(For Structure, see paper copy)

Synonyms Green salt.

\* Identifiers

- 1. CAS 10049-14-6. 2. RTECS: None.
- Specific DOT number: None.
- Specific DOT label: None
- \* Appearance and odor

Uranium tetrafluoride is a nonvolatile, green, odorless, crystalline solid.

#### CHEMICAL AND PHYSICAL PROPERTIES

- \* Physical data
  - Molecular weight: 314.
  - Boiling point (760 torr): 1417 degrees C (2582 degrees F).
  - Specific gravity (water = 1): 6.7 at 20 degrees C (68 degrees F).
  - Vapor density: Not applicable.

  - Melting point: 955-965 degrees C (1751-1769 degrees F). Vapor pressure at 20 degrees C (68 degrees F): Nearly zero.
  - Solubility: Insoluble in water; soluble (decomposes) in concentrated acids and alkalies.
  - Evaporation rate: Not applicable
- \* Reactivity
  - 1. Conditions contributing to instability: Heat, flame, or exposure to air. Uranium metal reacts with nearly all nonmetals. Uranium turnings and fines stored out-of-
  - doors in closed containers under water or water-soluble oil will convert partially to the hydride and will eventually ignite during hot weather.

    2. Incompatibilities: Pure uranium is very reactive and is a strong reducing agent. Clean uranium turnings or chips oxidize readily in air. Contact of uranium with carbon dioxide, carbon tetrachloride, or nitric acid causes fires or explosions. Uranium hydride is spontaneously flammable in air, and contact of the hydride with strong oxidizers may cause fires and explosions. Contact of uranium hydride with water forms flammable and explosive hydrogen gas, and contact of the hydride with halogenated hydrocarbons can cause violent reactions. In finely divided form, uranium dioxide ignites spontaneously in air
  - Hazardous decomposition products: Toxic particulates, gases, and vapors (such as uranium metal fume, oxides of uranium, hydrogen fluoride, carbon monoxide, and dangerous radioactive materials) may be released when uranium or an insoluble uranium compound decomposes.
  - Special precautions: Uranium is radioactive and highly reactive and should be handled with extreme caution at all times. Uranium tetrafluoride is highly corrosive.

The National Fire Protection Association has not assigned a flammability rating to uranium or the insoluble uranium compounds. Other sources rate uranium in solid or powder form as a very dangerous fire hazard when this substance is exposed to heat or open flame.

- 1. Flash point: Data not available.
  - Autoignition temperature: The ignition temperature depends on the extent to which the metal is subdivided. The ignition temperature of the metal is 170 degrees C (338 degrees F) (if oxygen is present); finely divided uranium metal (dust) ignites at room temperature (20 degrees C (68 degrees F))
- Flammable limits in air: Not applicable.
- Minimum explosive concentration: 60 g/m(3)
- Extinguishant: Use graphite chips, carbon dust, asbestos blankets, or flooding with water to extinguish small uranium fires. There is no effective way to extinguish large uranium fires.

Fires involving uranium or an insoluble uranium compound should be fought upwind and from the maximum distance possible. Keep unnecessary people away; isolate hazard area and deny entry. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Finely divided uranium (chips, turnings, shavings, etc.) are much more reactive than uranium in bulk form. If these are present during a fire, do not disperse them into a dust cloud, which may be explosive. Uranium metal may ignite spontaneously if exposed to air or other substances, may burn rapidly with a flare-burning effect, and may re-ignite after the fire has been extinguished. Containers of uranium or an insoluble uranium compound may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Personnel should withdraw immediately if a rising sound from a venting safety device is heard or if there is discoloration of a container due to fire. Dikes should be used to contain fire-control water for later disposal. If a tank car or truck is involved in a fire, personnel should isolate an area of a half a mile in all directions. Delay cleanup until arrival of, or instruction from, a qualified radiation authority. Firefighters should wear a full set of protective clothing, including a self-contained breathing apparatus, when fighting fires involving uranium or an insoluble uranium compound. Firefighters' protective clothing may provide limited protection against fires involving uranium or an insoluble uranium compound.

No quantitative data are available on the odor threshold for uranium or insoluble uranium compounds; several of these substances are odorless. For the purpose of selecting appropriate respiratory protection, these substances are therefore considered to have inadequate odor warning properties.

\* Eve irritation properties

No quantitative data are available on the eye irritation threshold for uranium or the insoluble uranium compounds.

#### **EXPOSURE LIMITS**

The current Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs) for uranium and the insoluble uranium compounds (measured as uranium) are 0.2 milligram per cubic meter (mg/m(3)) of air as an 8-hour time-weighted average (TWA) concentration and 0.6 mg/m(3) as a 15-minute TWA short-term exposure limit (STEL). A STEL is the maximum 15-minute concentration to which workers may be exposed during any 15-minute period of the working day [29 CFR 1910.1000, Table Z-1-A]. The National Institute for Occupational Safety and Health (NIOSH) has not issued a recommended exposure limit (REL) for uranium or its insol uranium compounds; however, NIOSH concurs with the PEL established for this substance by OSHA [NIOSH 1988]. The American Conference of Governmental Industria Hygienists (ACGIH) has assigned uranium and the insoluble uranium compounds a threshold limit value (TLV) of 0.2 mg/m(3) as a TWA for a normal 8-hour workday an 40-hour workweek and a short-term exposure limit (STEL) of 0.6 mg/m(3) for periods not to exceed 15 minutes [ACGIH 1988, p. 37]. The OSHA and ACGIH limits are born the risk of kidney and blood disorders and on the radiological damage associated with exposure to uranium or an insoluble uranium compound.

#### **Evaluation**

#### **HEALTH HAZARD INFORMATION**

#### \* Routes of Exposure

Exposure to uranium or an insoluble uranium compound can occur via inhalation, ingestion, and eye or skin contact. Exposure to uranium trioxide can occur by absorptic through the skin, eyes, and mucous membranes.

- \* Summary of toxicology
- 1. Effects on Animals: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury to the kidneys and lungs of exposed animals [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and uranium compounds have the potential to cause radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. The inhalation toxicity of uranium and the insoluble compounds of uranium is much greater than their oral toxicity [Clayton and Clayton 1981, p. 2000]. No dietary amount of insoluble uranium compounds acceptable to rats was lethal, and no evidence of systemic poisoning developed after the application of an insoluble compound to rabbit skin [Clayton and Clayton 1981, p. 2000]. However, uranium trioxide is lethal when placed in the conjunctival sac of rabbits' eyes, and uranium tetrafluorid causes direct eye injury [Grant 1986, p. 965]. Acute inhalation exposure to 20-mg/m(3) concentrations of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore was occasionally fatal to some laboratory animals; exposure to a 2.5-mg/m(3) concentration of uranium tetrafluoride, uranium dioxide, or high-grade uranium ore caused mild or no renal damage and no fatalities in these animals [Clayton and Clayton 1981, p. 2001]. Chronic inhalation exposure to an insoluble uranium compound may produce radiation injury. In dogs and monkeys exposed to 5 mg/m(3) uranium dioxide for 6 hours/day, 5 days/week for up to 5 years, fibrotic changes suggestive of radiation injury were found in the tracheobronchial lymph nodes of both species and in the lungs of monkeys. No kidney damage w observed in these animals [Clayton and Clayton 1981, p. 2001]. Dogs tolerated inhalation of a 10-mg/m(3) concentration of uranium dioxide every day for 1 year dietary exposure to 10 g/kg/day for 1 year [Clayton and Clayton 1981, p. 2001-2002]. Rats injected with metallic uranium in the femoral bone marrow and
- 2. Effects on Humans: Metallic uranium and insoluble uranium compounds may produce both chemical poisoning and radiation injury [Clayton and Clayton 1981, p. 1996]. The insoluble uranium compounds are less toxic chemically than the soluble compounds, but uranium and all uranium compounds have the potential to ca radiation damage [Clayton and Clayton 1981, p. 2000; Klaassen, Amdur, and Doull 1986, p. 695]. Exposure to the dusts of uranium or to an insoluble uranium compound may cause respiratory irritation, cough, and shortness of breath [Genium MSDS 1988, No. 238]. Dermatitis has also been reported, and prolonged skir contact causes radiation injury to the basal cells [Proctor, Hughes, and Fischman 1988, p. 502]. Studies have shown that uranium workers are at increased risk of death from respiratory, lymphatic, and hematopoietic cancers; these deaths are presumed to be caused by radiation injury from radon gas, a byproduct of uraniu decay [Rom 1983, p. 688]. A study of the risk of respiratory deaths among uranium miners in the United States showed the following dose-response: miners exproccupationally for 5 to 9.9 years had a 2-fold increase in risk; miners exposed for 10 to 24.9 years had a 3.6-fold increase in risk; and those exposed for greater t 24.9 years had a 3.75-fold increase in risk. Smoking was shown both to increase the risk of death from respiratory disease and to shorten the neoplastic latency period [Clayton and Clayton 1981, pp. 2010-2011].
- \* Signs and symptoms of exposure
  - Acute exposure: The signs and symptoms of acute exposure to uranium or an insoluble uranium compound include respiratory irritation, cough, and shortness of breath.
  - 2. Chronic exposure: 2. Chronic exposure: The signs and symptoms of chronic exposure to uranium or an insoluble uranium compound include those of lung damag shortness of breath, dry or productive cough, rales, cyanosis, and clubbing of the fingers. Long-term exposure also may cause cancer of the blood-forming system the lymph system, and the respiratory tract, as well as anemia and leukopenia. The signs and symptoms of uranium-induced dermatitis may include irritation, redness, blistering, thickening, or hyperpigmentation of the skin.
- \* Emergency procedures:

In the event of an emergency, remove the victim from further exposure, send for medical assistance, and initiate the following emergency procedures:

- 1. Eye exposure: If uranium or an insoluble uranium compound gets into the eyes, immediately flush the eyes with large amounts of water for a minimum of 15 minutes, lifting the lower and upper lids occasionally. If irritation persists, get medical attention as soon as possible.
- Skin exposure: If uranium or an insoluble uranium compound contacts the skin, the contaminated skin should be washed with soap and water. Contaminated bod surfaces should immediately be decontaminated in accordance with radiation procedures. Get medical attention.
- 3. Inhalation: If uranium or an insoluble uranium compound is inhaled, move the victim at once to fresh air and get medical care as soon as possible. If the victim is breathing, perform cardiopulmonary resuscitation; if breathing is difficult, give oxygen. Keep the victim warm and quiet until medical help arrives.
- 4. Ingestion: If uranium or an insoluble uranium compound is ingested, give the victim several glasses of water to drink and then induce vomiting by having the vict touch the back of the throat with the finger or by giving syrup of ipecac as directed on the package. Do not force an unconscious or convulsing person to drink liquids or to vomit. Get medical help immediately. Keep the victim warm and quiet until medical help arrives.
- Rescue: Remove an incapacitated worker from further exposure and implement appropriate emergency procedures (e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard, 29 CFR 1910.1200). All workers should be familiar with emergency procedures and the location and proper use of emergency equipment.

#### **EXPOSURE SOURCES AND CONTROL METHODS**

The following operations may involve uranium and insoluble uranium compounds and lead to worker exposures to these substances:

- Mining, grinding, and milling of uranium ores
- Use in nuclear reactors as fuel and to pack nuclear fuel rods and in the production of nuclear weapons
- Burning of uranium metal chips and smelting operations
- Use in the ceramics industry for pigments, coloring porcelain, painting on porcelain, and enamelling

- Use as catalysts for many reactions, in gas manufacture, and in production of fluorescent glass
- Use in photographic processes, for alloying steel, in radiation shielding, and in aircraft counterweights
- Use as a source of plutonium and radium salts

#### Uranium hydride:

- \* Use as a lab source for pure hydrogen, for separation of hydrogen isotopes, and as a reducing agent Methods that are effective in controlling worker exposures to uranium and insoluble uranium compounds, depending on the feasibility of implementation, are
  - Process enclosure,
  - Local exhaust ventilation,
  - General dilution ventilation, and
  - Personal protective equipment.

The following publications are good sources of information on control methods:

- 1. ACGIH [1986]. Industrial ventilation--a manual of recommended practice. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
- 2. Burton DJ [1986]. Industrial ventilation--a self study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.
- 3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.
- 4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.
- 5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

#### MEDICAL MONITORING

Workers who may be exposed to chemical and radiation hazards should be monitored in a systematic program of medical surveillance that is intended to prevent occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety or health, early detection of adverse health effects, and referral of workers for diagnosis and treatment. The occurrence of disease or other work-related adverse health effects should prompt immediate evaluation of primary preventive measures (e.g., industrial hygiene monitoring, engineering controls, and persor protective equipment). A medical monitoring program is intended to supplement, not replace, such measures. To place workers effectively and to detect and control wor related health effects, medical evaluations should be performed (1) before job placement, (2) periodically during the period of employment, and (3) at the time of job transfer or termination.

#### \* Preplacement medical evaluation

Before a worker is placed in a job with a potential for exposure to uranium or an insoluble uranium compound, the examining physician should evaluate and document the worker's baseline health status with thorough medical, environmental, and occupational histories, a physical examination, and physiologic and laboratory tests appropria for the anticipated occupational risks. These should concentrate on the function and integrity of the kidneys, respiratory system, blood, liver, bone marrow, skin, and lymphatics. Medical monitoring for respiratory disease should be conducted using the principles and methods recommended by NIOSH and the American Thoracic Societ

A preplacement medical evaluation is recommended to assess an individual's suitability for employment at a specific job and to detect and assess medical conditions that may be aggravated or may result in increased risk when a worker is exposed to uranium or an insoluble uranium compound at or below the prescribed exposure limit. The examining physician should consider the probable frequency, intensity, and duration of exposure as well as the nature and degree of any applicable medical condition. S conditions (which should not be regarded as absolute contraindications to job placement) include a history and other findings consistent with diseases of the kidneys, respiratory system, blood, liver, bone marrow, skin, or lymphatics.

#### \* Periodic medical examinations and biological monitoring

Occupational health interviews and physical examinations should be performed at regular intervals during the employment period, as mandated by any applicable Federa State, or local standard. Where no standard exists and the hazard is minimal, evaluations should be conducted every 3 to 5 years or as frequently as recommended by a experienced occupational health physician. Additional examinations may be necessary if a worker develops symptoms attributable to uranium exposure. The interviews, examinations, and medical screening tests should focus on identifying the adverse effects of uranium on the kidneys, respiratory system, blood, liver, bone marrow, skin lymphatics. Current health status should be compared with the baseline health status of the individual worker or with expected values for a suitable reference population

Biological monitoring involves sampling and analyzing body tissues or fluids to provide an index of exposure to a toxic substance or metabolite. Urinary uranium concentrations correlate well with airborne uranium levels. Some sources report that urinary concen-trations of 50 pg uranium per liter of urine or 100 pg uranium per lit of urine correspond to constant daily exposures of approximately 0.05 mg/m(3) or 0.25 mg/m(3), respectively. Because there is great interindividual and intraindividual variability in urinary uranium concentrations, a pattern of urinary uranium excretion should be established for every exposed worker by sampling individuals at the same time on several different shifts and by sampling frequently.

 $^{\star}$  Medical examinations recommended at the time of job transfer or termination

The medical, environmental, and occupational history interviews, the physical examination, and selected physiologic or laboratory tests that were conducted at the time placement should be repeated at the time of job transfer or termination to determine the worker's medical status at the end of his or her employment. Any changes in the worker's health status should be compared with those expected for a suitable reference population. Because occupational exposure to uranium or an insoluble uranium compound may cause diseases with prolonged latent periods, the need for medical monitoring may extend well beyond the termination of employment.

#### **WORKPLACE MONITORING AND MEASUREMENT PROCEDURES**

Determination of a worker's exposure to airborne uranium or an insoluble uranium compound (measured as uranium) is made using a mixed cellulose ester filter (0.8 micron). Samples are collected at a maximum flow rate of 2 liters per minute until a maximum air volume of 960 liters is collected. Analysis is conducted by neutron activation. This method is included in the OSHA In-House Methods File.

#### **Controls**

#### PERSONAL HYGIENE PROCEDURES

If uranium or an insoluble uranium compound contacts the skin, workers should immediately wash the affected areas with soap and water. Contaminated body surfaces should immediately be decontaminated in accordance with radiation procedures.

Clothing contaminated with uranium or an insoluble uranium compound should be removed immediately, and provisions should be made for the safe removal of the chemical from the clothing. Persons laundering the clothes should be informed of the toxic and radioactive hazards of uranium.

A worker who handles uranium or an insoluble uranium compound should thoroughly wash hands, forearms, and face with soap and water before eating, using tobacco products, or using toilet facilities.

Workers should not eat, drink, or use tobacco products in areas where uranium or an insoluble uranium compound is handled, processed, or stored.

#### STORAGE

Uranium and insoluble uranium compounds should be stored in a cool, dry, well-ventilated area in tightly sealed containers that are labeled in accordance with OSHA's Hazard Communication Standard [29 CFR 1910.1200]. Containers of uranium or of insoluble uranium compounds should be protected from physical damage and should

stored separately from carbon dioxide, carbon tetra-chloride, nitric acid, air, nonmetals, heat, sparks, and open flame. Uranium hydride should not be allowed to contact water, strong oxidizers, or halogenated hydrocarbons. Because empty containers that formerly contained uranium or a uranium compound may still hold product residue they should be handled appropriately.

#### **SPILLS AND LEAKS**

In the event of a spill or leak involving uranium or an insoluble uranium compound, persons not wearing protective equipment and clothing should be restricted from contaminated areas until cleanup has been completed. A clean-up plan must be available to address an accidental leak or spill of uranium or an insoluble uranium compound because special radiation procedures are required and professional assistance is needed. The following steps should be undertaken following a spill or leak:

- 1. Do not touch the spilled material; stop the leak if it is possible to do so without risk.
- 2. Notify safety personnel.
- Remove all sources of heat and ignition.
- 4. Ventilate the area of the spill or leak.
- 5. Protect cleanup personnel from contact with or inhalation of uranium dust.

#### EMERGENCY PLANNING, COMMUNITY RIGHT-TO-KNOW, AND HAZARDOUS WASTE MANAGEMENT REQUIREMENTS

The Environmental Protection Agency's (EPA's) regulatory requirements for emergency planning, community right-to-know, and hazardous waste management may vary over time. Users are therefore advised to determine periodically whether new information is available.

#### \* Emergency planning requirements

Uranium and insoluble uranium compounds are not subject to EPA emergency planning requirements under the Superfund Amendments and Reauthorization Act (Title I

\* Reportable quantity requirements for hazardous releases

Employers are not required by the emergency release notification provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [ CFR Part 355.40] to notify the National Response Center of an accidental release of uranium or an insoluble uranium compound; there is no reportable quantity for these substances.

\* Community right-to-know requirements

Employers are not required by Section 313 of the Superfund Amendments and Reauthorization Act (SARA) to submit a Toxic Chemical Release Inventory form (Form R) EPA reporting the amount of uranium or an insoluble uranium compound emitted or released from their facility annually.

\* Hazardous waste management requirements

EPA considers a waste to be hazardous if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity, as defined in 40 CFR 261.21-261.24 Under the Resource Conservation and Recovery Act (RCRA), EPA has specifically listed many chemical wastes as hazardous. Although uranium and insoluble uranium compounds are not specifically listed as a hazardous waste under RCRA, EPA requires employers to treat any waste as hazardous if it exhibits any of the characteristics discussed above.

Providing more information about the removal and disposal of specific chemicals is beyond the scope of this guideline. EPA, U.S. Department of Transportation, and Stat and local regulations should be followed to ensure that removal, transport, and disposal of this substance are conducted in accordance with existing regulations. To be certain that chemical waste disposal meets EPA regulatory requirements, employers should address any questions to the RCRA hotline at (202) 382-3000 (in Washingtor D.C.) or toll-free at (800) 424-9346 (outside Washington, D.C.). In addition, relevant State and local authorities should be contacted for information on any requirements they may have for the waste removal and disposal of this substance.

#### RESPIRATORY PROTECTION

#### \* Conditions for respirator use

Good industrial hygiene practice requires that engineering controls be used where feasible to reduce workplace concentrations of hazardous materials to the prescribed exposure limit. However, some situations may require the use of respirators to control exposure. Respirators must be worn if the ambient concentration of uranium or at insoluble uranium compound exceeds prescribed exposure limits. Respirators may be used (1) before engineering controls have been installed, (2) during work operation such as maintenance or repair activities that involve unknown exposures, (3) during operations that require entry into tanks or closed vessels, and (4) during emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by NIOSH and the Mine Safety and Health Administra (MSHA).

#### \* Respiratory protection program

Employers should institute a complete respiratory protection program that, at a minimum, complies with the requirements of OSHA's Respiratory Protection Standard [29] CFR 1910.134]. Such a program must include respirator selection (see Table 1), an evaluation of the worker's ability to perform the work while wearing a respirator, the regular training of personnel, fit testing, periodic workplace monitoring, and regular respirator maintenance, inspection, and cleaning. The implementation of an adequat respiratory protection program (including selection of the correct respirator) requires that a knowledgeable person be in charge of the program and that the program be evaluated regularly. For additional information on the selection and use of respirators and on the medical screening of respirator users, consult the **NIOSH Guide to Industrial Respiratory Protection**.

Table 1 lists the respiratory protection that NIOSH recommends for workers exposed to uranium or an insoluble uranium compound. The recommended protection may over time because of changes in the exposure limit for uranium or the insoluble uranium compounds or in respirator certification requirements. Users are therefore advis to determine periodically whether new information is available.

#### PERSONAL PROTECTIVE EQUIPMENT

Protective clothing should be worn to prevent skin contact with uranium or an insoluble uranium compound. Impervious gloves, boots, and aprons should be worn as appropriate when handling any of these substances. Chemical protective clothing should be selected on the basis of available performance data, manufacturers' recommendations, and evaluation of the clothing under actual conditions of use. No reports have been published on the resistance of various protective clothing materia permeation by uranium or an insoluble uranium compound; however, one source recommends natural rubber, neoprene, or polyvinyl chloride as a protective clothing material. If permeability data are not readily available, protective clothing manufacturers should be requested to provide information on the best chemical protective clothing for workers to wear when they are exposed to uranium or an insoluble uranium compound.

If uranium or an insoluble uranium compound is dissolved in an organic solvent, the permeation properties of both the solvent and the mixture must be considered wher selecting personal protective equipment and clothing.

Safety glasses, goggles, or faceshields should be worn during operations in which uranium or an insoluble uranium compound might contact the eyes. Eyewash fountain and emergency showers should be available within the immediate work area whenever the potential exists for eye or skin contact with uranium or its insoluble compoun Contact lenses should not be worn if the potential exists for exposure to any of these substances.

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## **Reference Table**

Table 1
NIOSH recommended respiratory protection for workers exposed to uranium or an insoluble uranium compound\*

Condition	Minimum respiratory protection**			
Airborne concentration of uranium or an insoluble uranium compound:				
0.2 to 2 mg/m(3) (10 X PEL)	Single-use or quarter mask respirator			
5 to 50 mg/m(3) (10 X PEL)	Any air-purifying, half-mask respirator equipped with a fume or high- efficiency filter approved for radon daughters or radionuclides, or			
	Any air-purifying, full-facepiece respirator equipped with a fume filter approved for radon daughters, or			
	Any supplied-air respirator equipped with a half mask and operated in a			

	demand (negative-pressure) mode
0.2 to 5 mg/m(3) (25 X PEL)	Any powered, air-purifying respirator equipped with a hood or helmet and a fume or high-efficiency filter approved for radon daughters or radio-nuclides, or Any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode
0.2 to 10 mg/m(3) (50 X PEL)	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radio-nuclides, or
	Any powered, air-purifying respirator equipped with a tight-fitting facepiece and a high-efficiency filter approved for radon daughters or radio-nuclides, or
	Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode, or
	Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous-flow mode, or
	Any self-contained respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode
0.2 to 30 mg/m(3) (150 X PEL)	Any supplied-air respirator operated in a pressure-demand or other positive pressure mode
Entry into IDLH(+) or unknown concentrations	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode, or
	Any supplied-air respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode
Firefighting	Any self-contained respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode
Escape	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter approved for radon daughters or radionuclides, or
	Any escape-type, self-contained breathing apparatus with a suitable service life (number of minutes required to escape the environment)

<sup>\*</sup> The OSHA PEL is 0.2 mg/m(3) as an 8-hour TWA. No NIOSH REL has been issued.

- Respirators accepted for use at higher concentrations may be used at lower concentrations; respirators must not, however, be used at concentrations higher than those for which they are approved.
- Air-purifying respirators may not be used in oxygen-deficient atmospheres or in airborne concentrations that are immediately dangerous to life or health (IDLH).
- (+) The uranium or an insoluble uranium compound concentration that is immediately dangerous to life and health (IDLH) is 30 mg/m(3) [NIOSH 1987b].

Introduction | Applicability | Recognition | Evaluation | Controls | References | Bibliography | Reference Table

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 $<sup>^{\</sup>star\star}$  Only NIOSH/MSHA-approved equipment should be used. Also note the following:

## HEAT STRESS PREVENTION AND TREATMENT

Elevated temperatures are potentially hazardous, especially when work is conducted without appropriate precautions. The following sections describe heat stress prevention and the recognition and treatment of heat emergencies.

#### Effects of Heat

A predictable amount of heat is generated as a result of normal oxidation processes within the body. If heat is liberated rapidly, the body cools to a point at which the production of heat is accelerated, and the excess heat brings the body temperature back to normal.

Interference with the elimination of heat leads to its accumulation and to the elevation of body temperature. This condition produces a vicious cycle in which certain body processes accelerate and generate additional heat. Afterward, the body must eliminate not only the heat that is normally generated but also the additional quantities of heat.

Most body heat is brought to the surface by the bloodstream and escapes to cooler surroundings by conduction and radiation. If moving air or a breeze strikes the body, additional heat is lost by convection. When the temperature of the surrounding air becomes equal to or rises above the body temperature, all the heat must be lost by vaporization of the moisture or sweat from skin surfaces. As the air becomes more humid (contains more moisture), vaporization from the skin decreases. Weather conditions including high temperatures (90 to 100 degrees F), high humidity, and little or no breeze cause the retention of body heat. Such conditions or a succession of such days (a heat wave) increase the chances of a medical emergency due to heat.

## **Preventing Emergencies Due to Heat**

When working in situations where the ambient temperatures and humidity are high, and especially in situations where protection levels A, B, or C are required, the site safety officer should:

- Ensure that all employees drink plenty of fluids (Gatorade or its equivalent);
- Ensure that frequent breaks are scheduled so overheating does not occur; and
- Revise work schedules, when necessary, to take advantage of the cooler parts of the day (i.e., 5:00 a.m. to 11:00 a.m. and 6:00 p.m. to nightfall).

When protective clothing is required, the suggested guidelines correlating ambient temperature and maximum wearing time per excursion are:

Ambient Temperature	Maximum Wearing Time per Excursion
Above 90 degrees F	15 minutes
85 to 90 degrees F	30 minutes
80 to 85 degrees F	60 minutes
70 to 80 degrees F	90 minutes
60 to 70 degrees F	120 minutes
50 to 60 degrees F	180 minutes

One method of measuring the effectiveness of an employee's rest-recovery regime is by monitoring the heart rate. The "Brouha guideline" is one such method and is performed as follows:

- Count the pulse rate for the **last** 30 seconds of the first minute of a 3-minute period, the **last** 30 seconds of the second minute, and the **last** 30 seconds of the third minute; and
- Double each result to yield beats per minute.

If the recovery pulse rate during the last 30 seconds of the first minute is 110 beats/minute or less, and the deceleration between the first, second, and third minutes is **at least** 10 beats/minute, then the work-recovery regime is acceptable. If the employee's rate is above the rate specified, a longer rest period will be required, accompanied by an increased intake of fluids.

#### **Heat Emergencies**

**Heat Cramps**. Heat cramps usually affect people who work in hot environments and perspire a great deal. Loss of salt from the body causes very painful cramps in leg and abdominal muscles. Heat cramps may also result from drinking iced water or other drinks either too quickly or in too large a quantity. The symptoms of heat cramps are:

- Painful muscle cramps in legs and abdomen;
- Faintness; and
- Profuse perspiration.

To provide emergency care for heat cramps, move the patient to a cool place. Give him or her sips of liquids such as Gatorade or its equivalent. Apply manual pressure to the cramped muscle. Move the patient to a hospital if there is any indication of a more serious problem.

**Heat Exhaustion**. Heat exhaustion also may occur in individuals working in hot environments and may be associated with heat cramps. Heat exhaustion is caused by the pooling of blood in the vessels of the skin. The heat is transported from the interior of the body to the surface by the blood. The skin vessels become dilated and a large amount of blood is pooled in the skin. This condition, plus the blood that is pooled in the lower extremities when in an upright position, may lead to an inadequate return of blood to the heart and eventual physical collapse. The symptoms of heat exhaustion are:

• Weak pulse;

- Rapid and usually shallow breathing;
- Generalized weakness;
- Pale, clammy skin;
- Profuse perspiration;
- Dizziness/faintness: and
- Unconsciousness.

To provide emergency care for heat exhaustion, move the patient to a cool place and remove as much clothing as possible. Have the patient drink cool water, Gatorade, or its equivalent. If possible, fan the patient continually to remove heat by convection, but do not allow chilling or overcooling. Treat the patient for shock and move him or her to a medical facility if there is any indication of a more serious problem.

**Heat Stroke**. Heat stroke is a profound disturbance of the heat-regulating mechanism and is associated with high fever and collapse. It is a serious threat to life and carries a 20% mortality rate. Sometimes this condition results in convulsions, unconsciousness, and even death. Direct exposure to sun, poor air circulation, poor physical condition, and advanced age (over 40) increase the chance of heat stroke. Alcoholics are extremely susceptible. The symptoms of heat stroke are:

- Sudden onset;
- Dry, hot, and flushed skin;
- Dilated pupils;
- Early loss of consciousness;
- Full and fast pulse;
- Deep breathing at first, followed by shallow or faint breathing;
- Muscle twitching, growing into convulsions; and
- Body temperature reaching 105 to 106 degrees F or higher.

When providing emergency care for heat stroke, remember that it is a life-threatening emergency. Transportation to a medical facility should not be delayed. Move the patient to a cool environment, if possible, and remove as much clothing as possible. Ensure an open airway. Reduce body temperature promptly by dousing the body with water or, preferably, by wrapping the patient in a wet sheet. If cold packs are available, place them under the arms, around the neck, at the ankles, or any place where blood vessels that lie close to the skin can be cooled. Protect the patient from injury during convulsions.





#### **Rodents, Snakes and Insects**

#### **Insects, Spiders and Ticks**

- To protect yourself from biting and stinging insects, wear long pants, socks, and long-sleeved shirts.
- Use insect repellents that contain DEET or Picaridin.
- Treat bites and stings with over-the-counter products that relieve pain and prevent infection.
- Avoid fire ants; their bites are painful and cause blisters.
- Severe reactions to fire ant bites (chest pain, nausea, sweating, loss of breath, serious swelling or slurred speech) require immediate medical treatment.

#### **Rodents and Wild or Stray Animals**

- Dead and live animals can spread diseases such as Rat Bite Fever and Rabies.
- Avoid contact with wild or stray animals.
- Avoid contact with rats or rat-contaminated buildings. If you can't avoid contact, wear protective gloves and wash your hands regularly.
- Get rid of dead animals as soon as possible.
- If bitten/scratched, get medical attention immediately.

#### Snakes

- Watch where you place your hands and feet when removing debris. If possible, don't place your fingers under debris you are moving. Wear heavy gloves.
- If you see a snake, step back and allow it to proceed.
- Wear boots at least 10 inches high.
- Watch for snakes sunning on fallen trees, limbs or other debris.
- A snake's striking distance is about 1/2 the total length of the snake.
- If bitten, note the color and shape of the snake's head to help with treatment.
- Keep bite victims still and calm to slow the spread of venom in case the snake is poisonous. Seek medical attention as soon as possible.
- Do not cut the wound or attempt to suck out the venom. Apply first aid: lay the person down so that the bite is below the level of the heart, and cover the bite with a clean, dry dressing.

#### For more complete information:



OSHA 3274-09N-05

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# **OSHA Fact Sheet**

# Protect Yourself! Workers may be exposed to

# Black Widow Spider

The black widow belongs to a group of spiders commonly known as cobweb spiders. The characteristic hourglass is located on the underside of the abdomen. Female black widows are dangerous and can bite and inject toxic venom.

#### Identification

- The female black widow is normally shiny black, with a red hourglass marking (see photo) on the underside of the abdomen.
- The abdominal marking may range in color from yellowish orange to red and its shape may range from an hourglass to a dot.
- The body of an adult black widow female is about 1/2 inch long.



**Symptons** 

The black widow is commonly found in the following places:

- Outdoors woodpiles, rubble piles, under stones, in hollow stumps, and in rodent burrows, privies, sheds and garages.
- Indoors undisturbed, cluttered areas in basements and crawl spaces.

may go unnoticed.

abdominal muscles.

The bite of the black widow may be painful or it

· The skin may display one or two bite marks with

local swelling. Pain usually progresses from the

bite site and eventually to the abdomen and back.

Severe cramping or rigidity may occur in the



Photo: Extension Entomology, Texas A&M University



Photo: University of Missouri Extension

- Symptoms may include nausea, profuse perspiration, tremors, labored breathing, restlessness, increased blood pressure and fever.
- The pain from the bite will usually persist for the first 8-12 hours.
- Symptoms may continue for several days.

#### Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling boxes, firewood, lumber, and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

#### Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the extremity.
- Capture the spider, if at all possible, for identification purposes.
- · Seek medical attention immediately.
- If you have a heart condition or other heart problem, you may need hospitalization.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

For more complete information:



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# **OSHA Fact Sheet**

# Protect Yourself! Workers may be exposed to

# Brown Recluse Spider

The brown recluse belongs to a group of spiders commonly known as violin spiders or fiddlebacks. The characteristic fiddle-shaped pattern is located on the top of the leg attachment region (cephalothorax). Because they are secluded and withdrawn, as their name implies, the brown recluse avoids open spaces. Brown recluse spiders are dangerous and they can bite and inject toxic venom.

#### Identification

- Body size: 1/4 to 3/4 inch (6.4-19.1mm)
- · Color: Golden brown
- A dark violin/fiddle shape (see top photo) is located on the top of the leg attachment region (cephalothorax) with the neck of the violin/fiddle pointing backward toward the abdomen.
- Unlike most spiders that have 8 eyes, the brown recluse has 6 eyes. The eyes, arranged in pairs – one pair in front and a pair on either side – can be readily seen under low magnification.



The Brown Recluse Spider builds small retreat webs behind objects of any type.

#### **Symptoms**

- The severity of the bite may vary. Symptoms may vary from none to very severe.
- The bite generally becomes reddened within several hours.

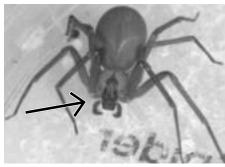


Photo: R. Bessin, University of Kentucky



Photo: creatures.ifas.ufl.edu

- There is often a systemic reaction within 24-36 hours characterized by restlessness, fever, chills, nausea, weakness and joint pain.
- Tissue at the site of the bite and the surrounding area dies and eventually sheds.

#### Protection

- Wear a long-sleeved shirt, hat, gloves, and boots when handling stored boxes, firewood, lumber and rocks, etc.
- Inspect and shake out clothing and shoes before getting dressed.
- Use insect repellants, such as DEET or Picaridin, on clothing and footwear.

#### Treatment

- Clean the bite area with soap and water.
- Apply ice to the bite area to slow absorption of the venom.
- Elevate and immobilize the bitten extremity.
- Capture the spider, if at all possible, for identification purposes.
- · Seek medical attention.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

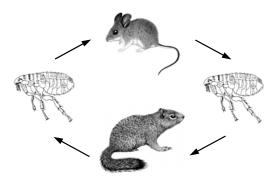
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# What is Plague?

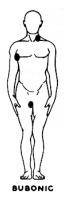


Plague is a disease of wild rodents and rabbits caused by the bacterium *Yersinia pestis*. It is spread among animals and to humans by the bites of infected fleas. Animals most often infected include rock squirrels, prairie dogs, pack rats, chipmunks, rabbits and mice.

When an animal with plague dies, the infected fleas must find a new host. This may be another rodent, a pet or a person.

Although most human plague cases result from flea bites, people have also contracted the disease by coming into direct contact with an infected animal's blood or tissues, such as when skinning a rabbit or other game.

People can also get plague by inhaling infectious droplets expelled by a person or cat with pneumonic plague.





# The three forms of plague are bubonic ...

Symptoms usually develop within two to six days after a flea bite or contact with an infected animal and include high fever, chills, weakness, headache and muscle aches. In bubonic plague, a lymph node in the groin, armpit or neck becomes swollen and very painful.

# ... septicemic ...

Sometimes the bacteria go directly into the blood and there are no swollen lymph nodes, just fever and severe flu-like symptoms. Secondary septicemic plague can result from untreated bubonic plague.

# ... and pneumonic.

If the bacteria invade the lungs, pneumonia may develop and the disease may be spread to other people when the patient coughs or sneezes. For plague pneumonia patients, the death rate is over 50%.



# Plague is curable if treated in time.

See your doctor immediately about any illness having sudden onset of high fever. Report if you have had flea bites, have handled any wild rodents or rabbits, or have a pet that hunts. Plague is curable with antibiotics if promptly diagnosed and treated.

Pets that hunt may bring plague-infected fleas into the home and can also become infected with plague. Cats are more likely than dogs to get sick, and can spread the disease to their owners through biting, coughing, or draining abscesses. Take your pet to the vet immediately if it has had contact with rodents and develops symptoms of fever, lethargy, and loss of appetite.

# **Preventing Plague**

- Avoid contact with wild rodents and their fleas, nests and burrows.
- Prevent pets from hunting.
- Treat outdoor pets with flea control products regularly.
- Wear rubber gloves when handling game.
- Eliminate rodent shelter around the home:
- Stack woodpiles at least 12" above the ground and 100 feet from the house;
- Keep animal feed in rodent-proof containers;
- Get rid of junk piles and abandoned vehicles around the home.
- Report sick or dead rodents and rabbits (in the absence of poisoning or trauma) to the Zoonoses Program in the New Mexico Department of Health. (Within Bernalillo County, contact the Albuquerque Environmental Health Dept.)

# For more information, contact:

Zoonoses Program
Epidemiology & Response
NM Department of Health
1190 St. Francis Dr.
Santa Fe, NM 87505

(505) 827-0006



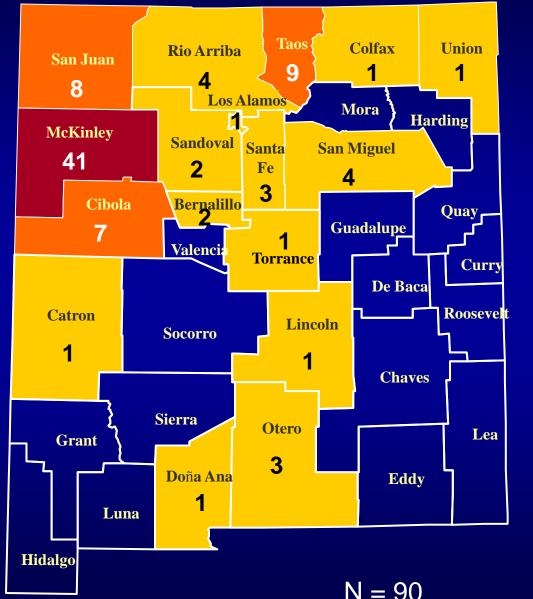
# PLAGUE IN NEW MEXICO





New Mexico Department of Health Epidemiology and Response Division

# HPS Cases in New Mexico by County, 1975 – 2011

















# **Notes From the Road**

#### Off-Road Driving and Safety Tips

By: Mac Demere/autoMedia.com

#### Speed is Not Your Friend -

Going off roading? Here are your choices: Carry your stuff on your back; walk beside a mule with your stuff on its back; ride in comfort with your stuff in the back of a four-wheeldrive.



The speed will be about the same. If you drive much faster than a walking pace there's a chance you'll be forced into the first option.

As a teenager, I wanted to cross a muddy section of field in a two-wheel-drive pickup on near-bald tires. I assessed that my only hope was speed. (If you ever say, "My only hope is ... " know that the rest of the sentence is "a miracle.") When the old Ford hit the swampy strip, it sunk floorboard-deep into the mud and came to a near-instant stop. The rear tires must have come off the ground because I feared it was about to flip forward.

Here are the lessons I should have learned, but didn't because I was a teenager:

#### Speed is not your friend.

The off-road driver's mantra is "As Slow As Possible, As Fast As Necessary." (The original author of this quote is uncertain, but I first heard it at a Land Rover driving school.) Sometimes a little speed may be required to climb a hill or conquer a hazard. However, if you think the obstacle requires even 10 mph, you're probably not going to make it. And you're going to damage something or get stuck.

#### Sometimes you can't get there from here.

This is true even with a well-equipped vehicle and a skilled driver—and was certainly true of an unskilled teenager in a poorly equipped vehicle. It's far easier to discover an alternate route than to find someone willing and able to come to your rescue. Walking the rest of the way is better than walking home.

#### Stay on the trail.

Trying to blaze my own trail not only got me stuck, but it left ruts that remained for years. Drive on previously used paths: You'll know it's possible to make it through there and you'll do less damage to the environment. A warning: Just because somebody else made it doesn't guarantee you will. Maybe they had a better vehicle, were a more skilled driver or went through before it rained.

#### Walk it first.

If you can't negotiate mud, sand or other obstacles on foot, it's highly unlikely your vehicle can make it. It's critical to check out a water-covered route: Unless you've seen another vehicle go through it, you can't be certain it doesn't hide a huge hole.

#### Be willing to walk back.

Never tackle a questionable obstacle unless you're able to walk back to where help awaits. If you're going off road, your cell phone will be useless. Even if there is coverage, there's nobody to call unless you've made a prior arrangement. The road-service tow-truck driver won't leave the pavement, the farmer with the tractor might not be home, and the guy in the SUV you wave down on the highway may not be able or willing to help. Not all SUVs have four-wheel-drive and a tow

strap.

#### Re-tire to succeed.

Even the most technologically advanced four-wheel-drive system can't make up for tires that are not meant for the job or lack adequate tread depth. Some original equipment tires on SUVs and pickups can't conquer anything more rigorous than wet grass. Also, even the best mud tires become useless off road well before they run out of tread.

#### Help yourself.

If you're planning to regularly travel the road less paved, bring along some things that'll help you out of small jams: a hand winch (a.k.a. "come-along"), tow strap, high-lift jack, shovel, some wood blocks, and a first-aid kit. If you're going further than you can walk out, bring enough stuff (extra clothes, water, sleeping bag) to survive until somebody finds you.

#### Tell somebody.

Tell somebody where you're going and when you expect to be back. At least they'll know when and where to start searching.

I got out of that ancient incident unscathed, largely because within a short hike there was a tractor with the keys in it and a long chain. Bringing along some luck never hurts.

#### About the Author

Mac Demere is a writer, vehicle tester and race driver who competed in the NASCAR Southwest Tour and Rolex 24 Hours at Daytona.

Project# 002693.2164.01RA
TDD# TO2 09-11-10-0004
Source: ESRI Streetmaps

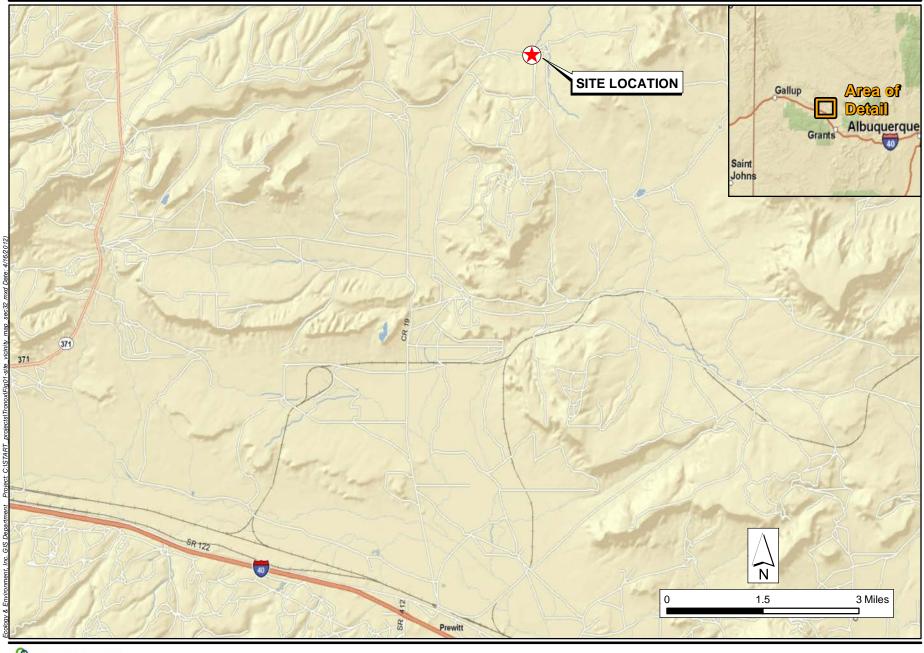
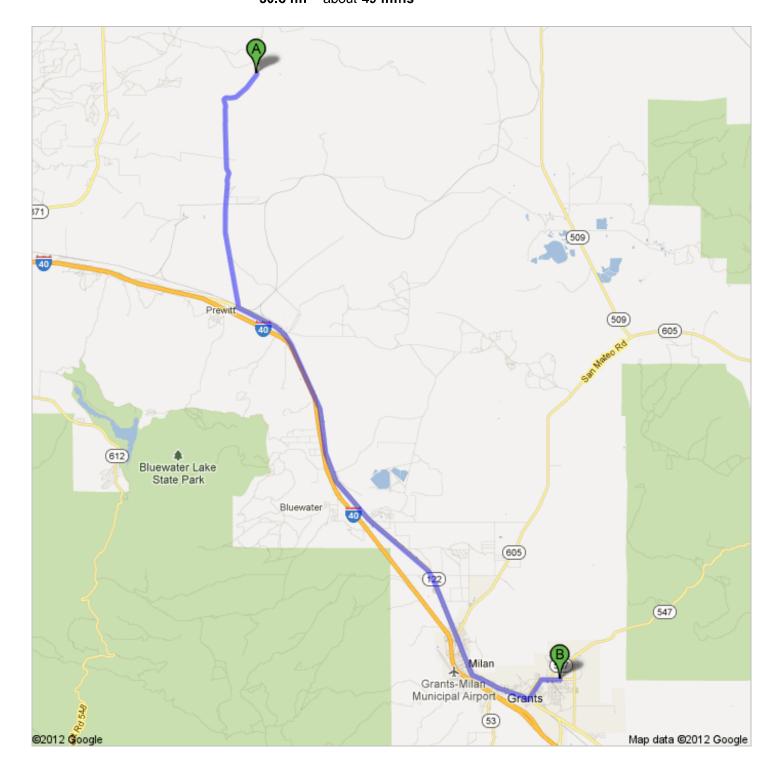




Figure 1
Site Vicinity Map
Tronox AUM Section 32
Casamero Lake Chapter, Navajo Nation, Prewitt, New Mexico



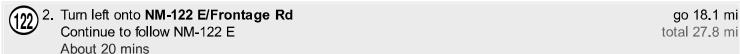
## Directions to Cibola General Hospital 1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446 30.8 mi – about 49 mins





#### Co Rd 19

1. Head southwest on Co Rd 19	go 9.7 mi
About 24 mins	total 9.7 mi



3. Continue onto **W Santa Fe Ave**About 2 mins
go 1.4 mi

4. Turn left onto 1	st St	go 0.9 mi
About 2 mins		total 30.0 mi

5. Slight right onto **W Roosevelt Ave**Destination will be on the left
About 2 mins

go 0.7 mi
total 30.8 mi



#### Cibola General Hospital

1016 E Roosevelt Ave, Grants, NM 87020 - (505) 287-4446

These directions are for planning purposes only. You may find that construction projects, traffic, we ather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route. Map data ©2012 Google

Directions weren't right? Please find your route on maps.google.com and click "Report a problem" at the bottom left.



# **Appendix C: Site Photographs**



# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

**Direction:** Southwest

**Date:** 10/13/12

# Description:

Incident Command
Post and support zone
during the removal
action



Direction: North **Date:** 10/17/12

# **Description:**

Air sampling during dust-generating activities





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200



**Date:** 10/18/12

# Description:

Documenting excavated area with a GPS



Direction: South **Date:** 10/19/12

## **Description:**

Dust control during excavation





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

Direction: North **Date:** 10/20/12

## **Description:**

Over excavation of the mine shaft located in AUM32-RA-04



Direction: West **Date:** 10/23/12

# **Description:**

Underground structures uncovered around the mine shaft during excavation





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

Direction: North **Date:** 10/29/12

# **Description:**

Surface gamma radiation survey of the excavation floor



Direction: North **Date:** 10/30/12

## **Description:**

Excavation of AUM32-RA-06 in the transfer area





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

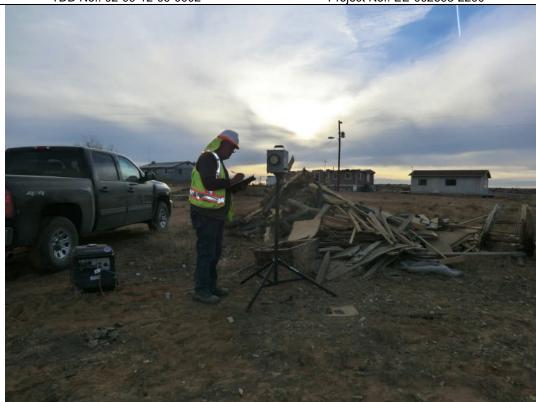
TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

Direction: West **Date:** 11/02/12

#### **Description:**

Air sampling between the removal area and the nearest residence



Direction:

**Date:** 11/03/12

## **Description:**

Pipes uncovered during excavation of AUM32-RA-12





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

**Direction:**Northwest

**Date:** 11/08/12

## **Description:**

Mine shaft at AUM32-RA-08



**Direction:** Downward

**Date:** 11/08/12

## **Description:**

Mine shaft uncovered during excavation at AUM32-RA-08



Page 6 of 8



# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002

Project No.: EE-002693-2200

Direction: North

**Date:** 11/09/12

## **Description:**

Removal activities at AUM 32



Direction: North **Date:** 11/14/12

# **Description:**

Spraying a soil stabilizer and dust control agent (Gorilla-Snot®) on the stockpile





# **Removal Action**

Tronox AUM Section 32 Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

Project No.: EE-002693-2200

TDD No.: 02-09-12-09-0002

Direction: East

Date: 11/14/12

# **Description:**

Surface gamma radiation survey of excavated areas



Direction: West

Date: 11/15/12

## **Description:**

Surface runoff drainage system for the stockpile





# **Appendix D: Tables**

## Table 1

# Removal Volumes Tronox AUM Section 32 Removal

## Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

	Pro	Proposed Excavation <sup>a</sup>		Final Excavation		ı
	Depth	Area	Volume	Depth	Area	Volume
Removal Area	(ft bgs)	(ft <sup>2</sup> )	(yd³)	(ft bgs)	(ft <sup>2</sup> )	(yd³)
AUM32-RA-01	3	23,222	2,580	1	25,040	927
AUM32-RA-02	2	105,402	7,808	2	55,567	4,116
AUM32-RA-03	1	60,850	2,254	1	64,133	2,375
AUM32-RA-04 <sup>b</sup>	3	88,704	9,856	1,3	31,413	2,809
AUM32-RA-05 <sup>b</sup>	4	30,454	4,512	4,6	21,181	3,834
AUM32-RA-15 <sup>c</sup>	0.5	30,961	573	0.5	30,961	573
AUM32-RA-16 <sup>c</sup>	0.5	9,902	183	0.5	9,902	183
AUM32-RA-17 <sup>d</sup>	1	14,164	525			
AUM 32 Mine Area		363,659	28,291		238,197	14,819
AUM32-RA-06	4	23,762	3,520	3	23,762	2,640
AUM32-RA-07	2	15,308	1,134	3	15,308	1,701
AUM32-RA-08 <sup>b</sup>	1	156,756	5,806	0.5,1	160,270	5,936
AUM32-RA-09	1	69,940	2,590	0.5,1	67,017	2,482
AUM32-RA-10	1	2,770	103	1	2,770	103
AUM32-RA-11	1	3,915	145	1	3,920	145
AUM32-RA-12	3	27,822	3,091	1	27,822	1,030
AUM32-RA-13	2	21,099	1,563	1	21,099	781
AUM32-RA-14 <sup>d</sup>	2	1,220	90			
AUM 32 Transfer Area		322,592	18,043		321,968	14,819
TOTAL		686,251	46,333		560,165	29,638

#### Notes:

a Proposed excavation information shown were from the Removal Assessment Report (E	&E 2012).
--	-----------

b The excavation volumes for AUM32-RA-04, -05, and -08 include overexcavated material from

mine shafts located in these removal areas.

c AUM32-RA-15 and -16 were delineated during the removal action and removed as shown in the

final excavation.

d AUM32-RA-14 and -17 were not excavated during this removal action. AUM32-RA-14 will be addressed

as part of AUM 33. AUM32-RA-17 was identified during the pre-excavation gamma radiation survey

but was not excavated by the Emergency and Rapid Response Services contractor.

AUM Abandoned Uranium Mine ft bgs Feet below ground surface

ft<sup>2</sup> Square feet yd<sup>3</sup> Cubic yards -- Not available

Table 2
Radium-226 Analytical Results and
Co-located Surface Gamma Radiation Activity
Tronox AUM Section 32 Removal
Casamero Lake Chapter, Navajo Nation
Prewitt, New Mexico

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

	Ra-226	Surface Gamma
Sample ID <sup>a</sup>	Concentration <sup>b</sup>	Radiation Activity <sup>c</sup>
'	(pCi/g)	(cpm)
AUM-32-RA-01-1	1.24	32,740
AUM-32-RA-01-2	1.36	32,887
AUM-32-RA-01-3	1.58	35,042
AUM-32-RA-02-1	1.43	34,008
AUM-32-RA-02-2	1.42	35,079
AUM-32-RA-02-3	1.4	34,622
AUM-32-RA-03-1	28.7	75,389
AUM-32-RA-03-2	1.88	35,779
AUM-32-RA-03-3	5.14	40,957
AUM-32-RA-03-30	5.83	40,957
AUM-32-RA-04-1	1.51	37,041
AUM-32-RA-04-2	1.03	29,344
AUM-32-RA-04-3	1.41	27,578
AUM-32-RA-05-1	1.81	38,837
AUM-32-RA-05-2	7.73	45,133
AUM-32-RA-05-3	3.32	40,183
AUM-32-RA-06-1	0.878	24,061
AUM-32-RA-06-2	1.53	27,216
AUM-32-RA-06-3	0.851	24,901
AUM-32-RA-07-1	1.28	25,021
AUM-32-RA-07-2	0.885	24,494
AUM-32-RA-07-3	1.35	25,548
AUM-32-RA-08-1	1.26	30,547
AUM-32-RA-08-2	31	79,831
AUM-32-RA-08-3	1.12	26,573
AUM-32-RA-08-30	1.08	26,573
AUM-32-RA-09-1	0.955	27,884
AUM-32-RA-09-2	1.06	27,720
AUM-32-RA-09-3	1.04	27,548
AUM-32-RA-10-1	15.5	96,449
AUM-32-RA-10-2	1.07	29,967
AUM-32-RA-10-3	1.17	30,558
AUM-32-RA-10-30	1.4	30,558
AUM-32-RA-11-1	1.06	28,945
AUM-32-RA-11-2	0.779	27,135
AUM-32-RA-11-3	2.52	29,944

Table 2

# Radium-226 Analytical Results and Co-located Surface Gamma Radiation Activity Tronox AUM Section 32 Removal

# Casamero Lake Chapter, Navajo Nation Prewitt, New Mexico

TDD No.: 02-09-12-09-0002 Project No.: EE-002693-2200

Sample ID <sup>a</sup>	Ra-226 Concentration <sup>b</sup> (pCi/g)	Surface Gamma Radiation Activity <sup>c</sup> (cpm)
AUM-32-RA-12-1	1.79	28,525
AUM-32-RA-12-2	31.4	40,567
AUM-32-RA-12-3	0.987	24,292
AUM-32-RA-13-1	3.24	28,502
AUM-32-RA-13-2	2.75	24,587
AUM-32-RA-13-3	0.89	26,807
AUM-32-RA-13-30	0.896	26,807
AUM-32-RA-15-1	18.3	61,801
AUM-32-RA-15-2	5.69	38,161
AUM-32-RA-15-3	3.3	35,913
AUM-32-RA-16-1	5.42	39,530
AUM-32-RA-16-2	6.09	37,415
AUM-32-RA-16-3	3.44	38,267
AUM-32-RA-16-30	3.16	38,267

#### Notes:

a The sample ID indicates the following:



- b Concentrations shown in **bold** exceed the action level of 2.11 pCi/g
- c Static 1-minute measurement at sampling location

AUM Abandoned uranium mine

cpm Counts per minute pCi/g Picocuries per gram

Ra-226 Radium-226



**Appendix E: Validated Analytical Data** 

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

Laboratory: GEL Laboratories	Lab Project Number: SDG 315573
Sampling Dates: November 15-16, 2012	Sample Matrix: Soil
Analytical Method: DOE HASL 300, 4.5,2.3/Ga-01-R, Gamma Spectroscopy	Data Reviewer: Joanna Z. Christopher

# **REVIEW AND APPROVAL:**

Data Reviewer: Schwitzcher	Date: <u>4/5//3</u>
Technical QA Reviewer:	Date: <u>4/5//3</u>
Project Manager:	Date:

Sample No.	Sample I.D.	Laboratory I.D.
1	AUM-32-RA-01-1	315573001
	AUM-32-RA-01-2	315573002
3	AUM-32-RA-01-3	315573003
2 3 4	AUM-32-RA-02-1	315573004
5 ·	AUM-32-RA-02-2	315573005
6 7	AUM-32-RA-02-3	315573006
7	AUM-32-RA-03-1	315573007
. 8	AUM-32-RA-03-2	315573008
9	AUM-32-RA-03-3	315573009
10	AUM-32-RA-03-30	315573010
11	AUM-32-RA-05-1	315573011
12	AUM-32-RA-05-2	315573012
13	AUM-32-RA-05-3	315573013
14	AUM-32-RA-04-1	315573014
15	AUM-32-RA-04-2	315573015
16	AUM-32-RA-04-3	315573016
17	AUM-32-RA-06-1	315573017
18	AUM-32-RA-06-2	315573018
19	AUM-32-RA-06-3	315573019
20	AUM-32-RA-07-1	315573020
21	AUM-32-RA-07-2	315573021
22	AUM-32-RA-07-3	315573022
23	AUM-32-RA-08-1	315573023
24	AUM-32-RA-08-2	315573024
25	AUM-32-RA-08-3	315573025
26	AUM-32-RA-08-30	315573026
27	AUM-32-RA-09-1	315573027
28	AUM-32-RA-09-2	315573028
29	AUM-32-RA-09-3	315573029
30	AUM-32-RA-11-1	315573030
31	AUM-32-RA-11-2	315573031
32	AUM-32-RA-11-3	315573032
33	AUM-32-RA-10-1	315573033

# Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	<b>Location:</b> Prewitt, McKinley County, New Mexico	
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200	

Sample No.	Sample I.D.	Laboratory I.D.
34	AUM-32-RA-10-2	315573034
35	AUM-32-RA-10-3	315573035
36	AUM-32-RA-10-30	315573036
37	AUM-32-RA-12-1	315573037
38	AUM-32-RA-12-2	315573038
39	AUM-32-RA-12-3	315573039
40	AUM-32-RA-13-1	315573040
41	AUM-32-RA-13-2	315573041
42	AUM-32-RA-13-3	315573042
43	AUM-32-RA-13-30	315573043
44	AUM-32-RA-15-1	315573044
45	AUM-32-RA-15-2	315573045
46	AUM-32-RA-15-3	315573046
47	AUM-32-RA-16-1	315573047
48	AUM-32-RA-16-2	315573048
49	AUM-32-RA-16-3	315573049
50	AUM-32-RA-16-30	315573050

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

#### T:

	DATA PACKAGE COMPLETENESS CHECKLIS
Checklist Code	:
X	_ Included: no problems
*	Included: problems noted in review
O	Not Included and/or Not Available
NR	Not Required
RS	Provided As Re-submission
Case Narrative:	
X	Case Narrative present
Quality Control	Summary Package:
X	Data Summary sheets
X	Initial and Continuing Calibration results
X	Detector Background Control Charts
X	Matrix Spike recoveries
X	Matrix Duplicate results
X	Laboratory Control Sample recoveries
X	Analysis Detection Limits
X	Preparation Log
X	Analysis Run Log
•	•
Raw QC Data P	ackage Section
X	Chain-of-Custody Records
X_	Instrument Printouts
X	Sample Preparation Notebook Pages
X	Logbook and Worksheet Pages
NR_	Percent Solids Determination

Comments: Soil samples were prepared using a dry soil preparation method and results were reported on a dry weight basis, therefore percent solids determination was not required.

For the soil gamma spec analysis there was a minimum 21-day ingrowth period for radon gas to decay to bismuth for analysis. The laboratory ingrowth period was 21 to 22 days, which was acceptable. The samples were analyzed 26 to 27 days after collection, which was acceptable.

Five field duplicate samples were collected, as required by the project Sampling and Analysis Plan (SAP). The field duplicate sample nomenclature was slightly different from that specified in the SAP.

No rinsate samples were required because dedicated sampling equipment was used.

Background samples were collected and analyzed during a previous sampling event.

#### **Tier 2 Validation**

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico	
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200	

#### **DATA VALIDATION SUMMARY**

The data were reviewed following procedures and limits specified in the EPA OSWER directive, Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures (EPA/540/G-90/004, OSWER Directive 9360.4-01, dated April 1990).

## Indicate with a YES or NO whether each item is acceptable without qualification:

1	Holding Times	Yes
2	Initial and Continuing Calibrations	Yes
3	Laboratory Control Sample	Yes
4	Matrix Spike	Yes
5	Blanks and Background Samples	Yes
6	Duplicate Analyses	Yes
7	Analyte Quantitation	Yes
8	Overall Assessment of Data	Yes
9	Usability of Data	Yes

Comments: None.

Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	<b>Location:</b> Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

1. HOLDING TIMES		
X Acceptable Acceptable with qualification Unacceptable		
Samples were extracted and analyzed within required holding times except as noted under Comments. In addition, no problems were identified with regard to sample preservation or custody unless specified. For those samples analyzed outside holding time requirements, the detected results have been qualified as estimated (J), and the nondetected results have been qualified either as estimated (UJ) or rejected (R) based on the reviewer's judgment.		
All Sample Matrices: Radiochemistry analyses: 6 months from collection to analysis.		
Comments: None.		
2. INITIAL AND CONTINUING CALIBRATION VERIFICATION		
X		
Unless flagged below, an initial calibration verification (ICV), background, and efficiency check were performed for each detector at the beginning of the run, and were within the laboratory acceptance limits.		
Commente: None		

Comments: None

**Tier 2 Validation** 

Site Name: Tronox AUM Sections 32 and 33	<b>Location:</b> Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

#### 3. LABORATORY CONTROL SAMPLE

	C. PADONATON TOOM NOT CARE PE
X	_ Acceptable
	Acceptable with qualification
	Unacceptable
	No Laboratory Control Samples Analyzed
(bias) i Sampli exceed In cas	tory control sample recoveries are used for a qualitative indication of accuracy independent of matrix effects. LCS recovery limits should either be specified in the ing and Analysis Plan or can be established by the laboratory. For analytes which led these control limits, associated detected results are qualified as estimated (J). es where the recovery was below 30%, all associated nondetected results are d (R) and detected results are qualified as estimated (J).
Comme	ents: None.
	4. MATRIX SPIKE
	Acceptable
	_ Acceptable with qualification
	Unacceptable
X	No Matrix Spikes Analyzed

Matrix spike recoveries are used for a qualitative indication of accuracy (bias) due to matrix effects. Unless flagged below, one matrix spike sample was analyzed at a rate of one per batch or one per 20 samples. Recoveries were within a range of 75-125%. For analytes which exceeded these control limits, associated detected results are qualified as estimated (J). In cases where the recovery was below 30%, all associated nondetected results are rejected (R) and detected results are qualified as estimated (J).

**Comments:** Matrix spike analysis (MS/MSD) was not required for gamma spec Ra-226 analysis and was not performed.

**Tier 2 Validation** 

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

#### 5. BLANKS AND BACKGROUND SAMPLES

X	Acceptable
	Detection Limits Adjusted
The follo	owing blanks were analyzed:
X_	Method (preparation) Blanks
	Field Blanks
X	Calibration Blanks (instrument background check)
	Rinsate Blanks
	Background Samples
prepara sample detected	tion (method) blanks were prepared for each batch of samples extracted. A tion blank was analyzed after every continuing calibration standard, prior to analysis unless noted below. Any radionuclide detected in the sample and also I in any associated blank, must be qualified as non-detect (U) when the sample ration is less than 5x the blank concentration.

#### Comments:

No sample results were qualified on the basis of blank samples.

#### Tier 2 Validation

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

#### 6. DUPLICATE ANALYSES

X	Acceptable
	Acceptable with qualification
	Unacceptable
	No Duplicates Analyzed
Type of	duplicates analyzed:
X	Field Duplicates
X	Laboratory Duplicates

Calculate the relative Percent Difference (RPD) between the members of duplicate pairs using the equation indicated below. Qualify the detected results as estimated (J) for any analyte whose RPD in a laboratory duplicate exceeds 20% for water samples or 35% for soil samples.

#### Comments:

The SAP requires collection of field duplicate samples at the rate of one for every ten samples. Five field duplicate sample pairs were collected for this sampling effort, which was acceptable. Precision was acceptable (≤35% RPD) for the field duplicate sample pairs, as shown below.

Field Duplicate Sample Pair	RPD
AUM-32-RA-03-3/AUM-32-RA-03-30	12.6
AUM-32-RA-08-3/AUM-32-RA-08-30	3.64
AUM-32-RA-10-3/AUM-32-RA-10-30	17.9
AUM-32-RA-13-3/AUM-32-RA-13-30	0.67
AUM-32-RA-16-3/AUM-32-RA-16-30	8.48

The laboratory performed one laboratory duplicate analysis for gamma spec analysis for every analytical batch of 20 samples or fewer, with acceptable precision.

#### **Tier 2 Validation**

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico				
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200				

## 7. ANALYTE QUANTITATION

# Confirm that analyte quantitation was performed correctly using the following formula:

Ra-226 (pci/g) =	gross sample cts - gross background counts
	2.22 X counting efficiency X sample mass X isotopic abundance X count time X ingrowth factor

Comments: 10% of the results were calculated and found to be correct, as shown below.

Ra-226 by gamma spec:

· · · · · · · · · · · · · · · · · ·	arriina op								
GEL		ingrowth			%	ct time,	calc	rpt	% calc
sample id	net cts	factor	% eff	Mass, g	abn	min	result	res	v rpt
315573012	4054	1	0.02748	157.57	0.455	120	7.7258	7.73	99.9456
315573026	281	1	0.02748	156.82	0.455	60	1.0761	1.08	99.6424
315573030	260	1	0.02579	157.00	0.455	60	1.0597	1.06	99.9761
315573039	234	1	0.02386	163.97	0.455	60	0.9871	0.987	100.0101
315573046	1191	1	0.0388	153.57	0.455	60	3.2988	3.3	99.9631

**Tier 2 Validation** 

Site Name: Tronox AUM Sections 32 and 33	Location: Prewitt, McKinley County, New Mexico
Project TDD Number: 02-09-12-09-0002	PAN: EE-002693-2200

Project 1DD Number: 02-09-12-09-0002	PAN: EE-002693-2200
,	
8. OVERALL ASSI	ESSMENT OF DATA
On the basis of this review, the following det overall data usability for the specified level.	termination has been made with regard to the
X Acceptable Acceptable with Qualification Rejected	
Any qualifications to individual sample analy section above or appear under the comments criteria are out of specification, it may be app. The data reviewer must use professional jud on the data validity for each specific data page.	s section below. In cases where several QC propriate to further qualify the data usability. gment and express concerns and comments
<b>Comments:</b> Ra-228 was detected in 43 of the s 0.83 to 2.09 pCi/g, likely due to radioactive deca detected in two samples in this SDG at low level atmospheric radioactive fallout.	
9. DOCUMENTATION OF LABO	RATORY CORRECTIVE ACTION
Problem: None.	
Resolution:	
Attached are copies of all data summary she of the chain of custody for the samples.	ets, with data qualifiers indicated, and a copy

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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-01-1

Project: Client ID: ECOL00724 ECOL007

Sample ID:

315573001

Matrix:

Collect Date:

Soil

Receive Date:

15-NOV-12 15:46 20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A <sub>1</sub>	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis							****		
Gamma, Ra226, S	Solid "Dry Weight (	Corrected'	1				*			
Radium-226		1.24	+/-0.181	0.124	1.00	pCi/g	M	XR1 12/12/12	0849 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		A	nalyst	Date	Time	Prep Batch	1	<del></del>
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	RS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alvst Comn	nents		
1	DOE HASL 30	00, 4.5.2.3/0	ia-01-R							



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# **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

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3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-01-2

315573002

20-NOV-12

Sample ID:

Matrix:

Soil

Collect Date:

15-NOV-12 15:50

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected	"							
Radium-226		1.36	+/-0.153	0.0984	1.00	pCi/g	M	XR1 12/12/12	0849 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1			Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021		DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

Efhistopher 4/5/13

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## **Certificate of Analysis**

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Address:

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#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-01-3

Project:

ECOL00724

Sample ID:

Client ID:

ECOL007

315573003

Matrix:

Soil

Collect Date:

15-NOV-12 15:54 20-NOV-12

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	ı <del>ı</del>							
Radium-226		1.58	+/-0.204	0.157	1.00	pCi/g	M	XR1 12/12/12	0905 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	N-021	1	DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description			***************************************		Ana	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

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Project:

Client ID:

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Report Date: December 14, 2012

Company:

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Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-02-1

315573004

Sample ID: Matrix:

Soil

Collect Date:

15-NOV-12 16:01

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis			,						
Gamma, Ra226, S	Solid "Dry Weight	Corrected <sup>1</sup>	"							
Radium-226		1.43	+/-0.158	0.110	1.00	pCi/g	M	XR1 12/12/12	0905 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	n		A	Analyst	Date	Time	Prep Batch	n	····
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Ι	DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASL 3	00. 4.5.2.3/0	Ga-01-R							

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Project:

Client ID:

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ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Cheff bang

Client Sample ID: AUM-32-RA-02-2

Sample ID:

315573005

Matrix:

Soil

Collect Date:

15-NOV-12 16:04

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis						111 1111 1111 1111			
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	1							
Radium-226	• • •	1.42	+/-0.149	0.108	1.00	pCi/g	M	XR1 12/12/12	0906 1265266	1
The following Pre	ep Methods were pe	rformed:								
Method	Description	1		A	nalyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	·-021	D	RS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods w	vere perfo	rmed:							
Method	Description					An	alyst Comr	nents		
1	DOE HASL 30	00, 4.5.2.3/0	3a-01-R				,	A-10-10-10-10-10-10-10-10-10-10-10-10-10-		

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-02-3

Project: Client ID: ECOL00724 ECOL007

Sample ID:

315573006

Matrix:

Soil

Collect Date:

15-NOV-12 16:08

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL.	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected	n							
Radium-226		1.40	+/-0.144	0.104	1.00	pCi/g	M	XR1 12/12/12	0906 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		F	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Ω	DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							



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Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-03-1

ECOL00724

Sample ID:

315573007

Project: Client ID:

ECOL007

Matrix:

Soil

Collect Date:

15-NOV-12 16:16

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch I	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected	1							
Radium-226		28.7	+/-0.541	0.194	1.00	pCi/g	M	XR1 12/12/12	0907 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		Α	nalyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	RS1	11/20/12	1400	1265149		***************************************
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	6a-01-R				•••			



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Client ID:

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ECOL007

Report Date: December 14, 2012

Company:

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Address:

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Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-03-2

Sample ID:

315573008

Matrix:

Soil

Collect Date:

15-NOV-12 16:23

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch l	Method
Rad Gamma Spec A	Analysis							,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
Gamma, Ra226, So	lid "Dry Weight	Corrected	,					,		
Radium-226		1.88	+/-0.162	0.0938	1.00	pCi/g	M	XR1 12/12/12	0907 1265266	1
The following Prep	Methods were pe	erformed:								
Method	Description	n			Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021		DRS1	11/20/12	1400	1265149		
The following Ana	lytical Methods v	vere perfo	rmed:							
Method	Description	l				An	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

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Project:

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Report Date: December 14, 2012

Company:

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Address:

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#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-03-3

315573009

Sample ID: Matrix:

Soil

Collect Date:

15-NOV-12 16:27

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected <sup>1</sup>	u.							
Radium-226		5.14	+/-0.342	0.203	1.00	pCi/g	M	XR1 12/12/12	0908 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n			Analyst	Date	Time	Prep Batch	n	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	1	DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							



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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action-

Client Sample ID: AUM-32-RA-03-30

Sample ID:

315573010

20-NOV-12

Matrix:

Soil

Collect Date:

15-NOV-12 16:28

Receive Date: Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF At	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected	н :							
Radium-226		5.83	+/-0.356	0.208	1.00	pCi/g	M	XR1 12/12/12	0940 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Γ	DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							



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Project:

Client ID:

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-05-1

Sample ID:

315573011

20-NOV-12

Matrix:

Soil

Collect Date:

16-NOV-12 10:49

Receive Date: Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected'	t							
Radium-226		1.81	+/-0.193	0.126	1.00	pCi/g	M	XR1 12/12/12	0940 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		A	nalyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	021	D	RS1	11/20/12	1400	1265149		
The following An	nalytical Methods v	vere perfo	rmed:							
Method	Description	l				An	alyst Comn	nents		
1	DOE HASL 3	00 4 5 2 3/0	Ga-01-R							



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### **Certificate of Analysis**

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Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-05-2

Project:

ECOL00724

Sample ID:

315573012

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 10:54

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis						MALO CONTRACTOR OF THE CONTRAC		,	
Gamma, Ra226, So	olid "Dry Weight (	Corrected	1							
Radium-226		7.73	+/-0.280	0.139	1.00	pCi/g	M	XR1 12/12/12	0941 1265266	1
The following Prej	p Methods were pe	erformed:								
Method	Description	1		F	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Γ	DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R				-			



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Project:

Client ID:

ECOL00724

ECOL007

# **Certificate of Analysis**

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#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-05-3

Sample ID:

315573013

Matrix:

Soil

Collect Date:

16-NOV-12 10:57

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF At	alyst Date	Time Batch	Method
Rad Gamma Spec	Analysis			, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,						
Gamma, Ra226, S	olid "Dry Weight (	Corrected'	11							
Radium-226		3.32	+/-0.184	0.104	1.00	pCi/g	M	XR1 12/12/12	0948 1265266	1
The following Pre	p Methods were pe	rformed:								
Method	Description	1		A	nalyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	RS1	11/20/12	1400	1265149		
The following An	alytical Methods w	ere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 30	00, 4.5.2.3/0	Ga-01-R		The second secon					

Ofhristopher 4/5/13

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### **Certificate of Analysis**

Report Date: December 14, 2012

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Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-04-1

ECOL00724

Sample ID:

315573014

Project: Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 11:12

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	н							
Radium-226		1.51	+/-0.189	0.130	1.00	pCi/g	M	XR1 12/12/12	0952 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		Į.	Analyst	Date	Time	Prep Batcl	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	X-021	Ι	DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-04-2

315573015

Sample ID: Matrix:

Soil

Collect Date:

16-NOV-12 11:17

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Oualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	•	Corrected	"							
Radium-226		1.03	+/-0.157	0.0924	1.00	pCi/g	M	XR1 12/12/12	0959 1265266	1
The following Pre	p Methods were p	erformed:								
Method	Description	n			Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Γ	DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	were perfo	rmed:							
Method	Description	l				Ana	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R				•			

Mistopher 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

# **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project: Client Sample ID: 2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

AUM-32-RA-04-3

Sample ID:

315573016

Matrix: Collect Date: Soil

Receive Date:

16-NOV-12 11:20 20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected	ıı							
Radium-226		1.41	+/-0.132	0.0949	1.00	pCi/g	M	XR1 12/12/12	1004 1265266	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021		DRS1	11/20/12	1400	1265149		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description	<u> </u>				An	alyst Comr	nents		
1	DOE HASL 3	00. 4.5.2.3/0	Ga-01-R				-			

Khristopher 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

Project:

Client ID:

ECOL00724

ECOL007

## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-06-1

Sample ID: Matrix:

315573017

Soil

Collect Date:

16-NOV-12 11:31

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	II							
Radium-226	, ,	0.878	+/-0.119	0.0892	1.00	pCi/g	M	XR1 12/12/12	1004 1265266	1
The following Pre	ep Methods were pe	rformed:								
Method	Description	1			Analyst	Date	Time	Prep Batcl	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	A-021		DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description		WWW.			Ana	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

Bhistohew 4/5/13

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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-06-2

Sample ID:

315573018

20-NOV-12

Matrix:

Soil

Collect Date:

16-NOV-12 11:34

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight (	Corrected'	ì							
Radium-226	, ,	1.53	+/-0.142	0.0927	1.00	pCi/g	M	XR1 12/12/12	1117 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		1	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Ι	DRS1	11/20/12	1400	1265149		
The following An	nalytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASI 3	00 4 5 2 3/6	a_01_R							

33 Christopher 4/5/13

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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-06-3

Sample ID:

315573019

Matrix:

Soil

Collect Date:

16-NOV-12 11:37

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected	1							
Radium-226	. 0	0.851	+/-0.197	0.141	1.00	pCi/g	M	XR1 12/12/12	1118 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	n			Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021		DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:	•						
Method	Description					An	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

33 histoher 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

ECOL00724

ECOL007

Client ID:

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-07-1

315573020

Sample ID:

Matrix:

Soil

Collect Date:

16-NOV-12 11:43

20-NOV-12

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected'								
Radium-226		1.28	+/-0.172	0.123	1.00	pCi/g	M	XR1 12/12/12	1149 1265266	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1			Analyst	Date	Time	Prep Batch		
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1400	1265149		
The following Ar	nalytical Methods v	vere perfo	rmed:						•	
Method	Description					Ana	alyst Comr	nents		
1	DOE HASL 3	00 4 5 2 3/0	a-01-R							

Hhristopher 4/5/13

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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-07-2 Sample ID:

315573021

Matrix:

Soil

Collect Date:

16-NOV-12 11:48

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF At	nalyst Date	Time Batch I	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected"								
Radium-226		0.885	+/-0.179	0.119	1.00	pCi/g	M	XR1 12/13/12	0808 1265268	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfor	med:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/G	a-01-R							

Shirtopher 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-07-3

Project:

ECOL00724

Sample ID:

Client ID:

ECOL007

315573022

Matrix:

Soil

20-NOV-12

Collect Date:

16-NOV-12 11:51

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch I	Method
Rad Gamma Spec	: Analysis				- 0					
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	n							
Radium-226		1.35	+/-0.176	0.127	1.00	pCi/g	M	XR1 12/13/12	0809 1265268	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1			Analyst	Date	Time	Prep Batch	n	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	****	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comr	nents		
1	DOE HASL 30	00. 4.5.2.3/0	7a-01-R							

23 Christopher 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-08-1

ECOL00724

Sample ID:

315573023

Project: Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 11:59

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight (	Corrected	"							
Radium-226		1.26	+/-0.223	0.141	1.00	pCi/g	M	XR1 12/13/12	0821 1265268	1
The following Pre	p Methods were pe	rformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	D	DRS1	11/20/12	1407	1265151		
The following An	nalytical Methods w	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 30	00, 4.5.2.3/0	3a-01-R							

33 Christopher 45/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-08-2

Project: Client ID: ECOL00724

Sample ID:

315573024

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 12:04

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected <sup>1</sup>	1							
Radium-226	, ,	31.0	+/-0.661	0.256	1.00	pCi/g	M	XR1 12/13/12	0822 1265268	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		1	Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comr	nents		
1	DOE HASL 3	00. 4.5.2.3/0	a-01-R							

J. Christophen 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-08-3

ECOL00724

Sample ID:

315573025

Project: Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 12:09

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch I	Method
Rad Gamma Spec	Analysis		•							
Gamma, Ra226, S	Solid "Dry Weight	Corrected	11							
Radium-226		1.12	+/-0.164	0.124	1.00	pCi/g	M	XR1 12/13/12	0822 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Ī	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description	l				Ana	alyst Comn	nents	-	
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

J3 Christopher 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-08-30

Project: Client ID: ECOL00724 ECOL007

Sample ID:

315573026.

Matrix:

Soil

Collect Date:

16-NOV-12 12:10

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected	"							
Radium-226		1.08	+/-0.180	0.131	1.00	pCi/g	M	XR1 12/13/12	0823 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		F	Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Ω	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R				•			

33 Christopher 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-09-1

Sample ID:

315573027

Matrix:

Soil

Collect Date:

16-NOV-12 13:05

Receive Date: Collector:

20-NOV-12 Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis								ALL AND	
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	n							
Radium-226		0.955	+/-0.179	0.134	- 1.00	pCi/g	M	XR1 12/13/12	0823 1265268	1
The following Pre	ep Methods were pe	rformed:								
Method	Description	1			Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	**************************	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comr	nents		
1	DOF HASU 3	00 4 5 2 3/0	7a-01-R							

2 Christopher 4/5/13

Project:

Client ID:

ECOL00724

ECOL007

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-09-2

Sample ID:

315573028

Matrix:

Soil

Collect Date:

16-NOV-12 13:10

Receive Date:

20-NOV-12

Collector:

Client

						·			
Parameter	Qualifier Re	esult	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch Method
Rad Gamma Spec	Analysis								
Gamma, Ra226, S	Solid "Dry Weight Corre	ected"							
Radium-226		1.06	+/-0.189	0.127	1.00	pCi/g	M.	XR1 12/13/12	0902 1265268 1
The following Pre	p Methods were perfor	rmed:							
Method	Description			Α	nalyst	Date	Time	Prep Batch	1
Dry Soil Prep	Dry Soil Prep GL-F	RAD-A-	021	D	RS1	11/20/12	1407	1265151	
The following Ar	nalytical Methods were	perfor	med:						
Method	Description	***************************************				Ana	alyst Comn	nents	
1	DOE HASL 300, 4.	.5.2.3/Ga	n-01-R						

Rhistopher 4/5/13

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# **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-09-3

Sample ID:

315573029

Matrix:

Soil

Collect Date:

16-NOV-12 13:12

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time	Batch I	Method
Rad Gamma Spec	Analysis		3								
Gamma, Ra226, S	Solid "Dry Weight	Corrected	t .								
Radium-226		1.04	+/-0.220	0.180	1.00	pCi/g	M	XR1 12/13/12	0902 12	65268	1
The following Pre	p Methods were pe	erformed:									
Method	Description	1		A	Analyst	Date	Time	Prep Batc	h		
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Ĺ	DRS1	11/20/12	1407	1265151			
The following Ar	nalytical Methods v	vere perfo	rmed:								
Method	Description					Ana	alyst Comn	nents			
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R								

JChristopher 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project: Client Sample ID: 2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

AUM-32-RA-11-1

Project: Client ID: ECOL00724 ECOL007

Sample ID:

315573030

Matrix:

Soil

Collect Date:

16-NOV-12 13:22

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, So	olid "Dry Weight	Corrected	n .							
Radium-226	, ,	1.06	+/-0.198	0.135	1.00	pCi/g	M	XR1 12/13/12	0903 1265268	1
The following Prep	Methods were pe	erformed:								
Method	Description	1		1	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	I	DRS1	11/20/12	1407	1265151		
The following Ana	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R			*	-			



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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-11-2

Project:

ECOL00724

Sample ID:

315573031

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 13:24

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected	11							
Radium-226	, ,	0.779	+/-0.205	0.203	1.00	pCi/g	M	XR1 12/13/12	0903 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Γ	DRS1	11/20/12	1407	1265151		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comr	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R				***************************************			



Project:

Client ID:

ECOL00724

ECOL007

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-11-3

Sample ID: Matrix:

315573032

20-NOV-12

Soil

Collect Date:

16-NOV-12 13:27

Receive Date: Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis					-				
Gamma, Ra226, S	Solid "Dry Weight	Corrected'	•							
Radium-226		2.52	+/-0.377	0.224	1.00	pCi/g	M	XR1 12/13/12	0903 1265268	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	6a-01-R							



Project:

Client ID:

ECOL00724 ECOL007

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-10-1

Sample ID:

315573033

Matrix:

Soil

Collect Date:

16-NOV-12 13:41

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis							,		
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	ıı.							
Radium-226	,	15.5	+/-0.609	0.241	1.00	pCi/g	M	XR1 12/13/12	0904 1265268	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	1		1	Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASL 3	00, 4,5,2,3/0	Ga-01-R							

33 Christopher 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-10-2

Project:

ECOL00724

Sample ID:

315573034

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 13:44

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, Sc	olid "Dry Weight	Corrected'								
Radium-226		1.07	+/-0.252	0.191	1.00	pCi/g	M.	XR1 12/13/12	0933 1265268	1
The following Prep	Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Γ	DRS1	11/20/12	1407	1265151		
The following Ana	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	a-01-R							

J3Christopher 4/5/13

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## **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-10-3

Project:

ECOL00724

Sample ID:

315573035

313

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 13:45

Receive Date: Collector:

20-NOV-12 Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected'	t							
Radium-226		1.17	+/-0.188	0.119	1.00	pCi/g	M	XR1 12/13/12	0933 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n			Analyst	Date	Time	Prep Batch	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Γ	DRS1	11/20/12	1407	1265151		
The following An	alytical Methods v	were perfo	rmed:							
3.4.1.1			***************************************							

Method

Description

DOE HASL 300, 4.5.2.3/Ga-01-R

Analyst Comments

3 Christopher 4/5/13

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## **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-10-30

315573036

Sample ID:

Matrix:

Soil

Collect Date:

16-NOV-12 13:46

Receive Date:

20-NOV-12

Collector:

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected <sup>1</sup>	1							
Radium-226		1.40	+/-0.228	0.175	1.00	pCi/g	M	XR1 12/13/12	0933 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Ι	DRS1	11/20/12	1407	1265151		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							



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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-12-1

Project:

ECOL00724

Sample ID:

315573037

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 13:52

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis		-							
Gamma, Ra226, Se	olid "Dry Weight	Corrected	11							
Radium-226		1.79	+/-0.252	0.148	1.00	pCi/g	M	XR1 12/13/12	0934 1265268	1
The following Prej	p Methods were pe	erformed:								
Method	Description	n		A	nalyst	Date	Time	Prep Batch	1 .	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	RS1	11/20/12	1407	1265151		
The following An	alytical Methods v	were perfo	rmed:							
Method	Description					Ana	alvst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	3a-01-R							



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# **Certificate of Analysis**

Report Date: December 14, 2012

ECOL00724

ECOL007

Client ID:

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

Client Sample ID:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Sample ID:

AUM-32-RA-12-2

315573038

Matrix:

Soil

Collect Date:

16-NOV-12 13:55

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	, RL	Units	DF Aı	nalyst Dat	e Time	Batch	Method
Rad Gamma Spec	Analysis										
Gamma, Ra226, S	Solid "Dry Weight (	Corrected	u .								
Radium-226		31.4		0.357	1.00	pCi/g	M	XR1 12/13/1	2 0934 13	265268	1
The following Pre	ep Methods were pe	erformed:			•						
Method	Description	1			Analyst	Date	Time	Prep Bat	ch		
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021		DRS1	11/20/12	1407	1265151	4.144		
The following Ar	nalytical Methods v	vere perfo	rmed:								
Method	Description					An	alyst Comr	nents			
1	DOE HASL 3	00, 4.5.2.3/0	3a-01-R				<b>-</b>				

3 Christopher 4/5/13

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Project:

Client ID:

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### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Sample ID:

Client Sample ID: AUM-32-RA-12-3

315573039

Matrix:

Soil

Collect Date:

16-NOV-12 13:57

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight C	Corrected	11							
Radium-226	, ,	0.987	+/-0.169	0.114	1.00	pCi/g	M	XR1 12/13/12	0937 1265268	1
The following Pre	ep Methods were pe	rformed:								
Method	Description			F	Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Γ	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods w	ere perfo	rmed:							
Method	Description					An	alyst Comn	nents		
1	DOE HASL 30	0, 4.5.2.3/0	Ga-01-R				<u>-</u>			

33 Christopher 4/5/13

Project:

Client ID:

ECOL00724

ECOL007

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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-13-1

315573040

Sample ID:

Matrix:

Soil

Collect Date:

16-NOV-12 14:01 20-NOV-12

Receive Date: Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected"	•							
Radium-226		3.24	+/-0.285	0.175	1.00	pCi/g	M	XR1 12/13/12	0935 1265268	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		A	Analyst	Date	Time	Prep Batch	l	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	E	DRS1	11/20/12	1407	1265151		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASI, 3	00. 4.5.2.3/6	a-01-R							



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### **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-13-2 Sample ID:

315573041

Matrix:

Soil

Collect Date:

16-NOV-12 14:04

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF At	nalyst Date	Time Batch I	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight Co	orrected"								
Radium-226	•	2.75	+/-0.178	0.105	1.00	pCi/g	M	XR1 12/12/12	1303 1265273	1
The following Pre	ep Methods were perf	formed:								
Method	Description				Analyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep G	L-RAD-A	-021	]	DRS1	11/20/12	1415	1265153		
The following Ar	nalytical Methods we	re perfoi	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 300,	, 4.5.2.3/G	a-01-R							



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Project:

Client ID:

ECOL00724

ECOL007

### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-13-3

Sample ID:

315573042

Matrix:

Soil

Collect Date:

16-NOV-12 14:07

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected <sup>1</sup>	II.							
Radium-226	, ,	0.890	+/-0.189	0.136	1.00	pCi/g	M	XR1 12/12/12	1311 1265273	1
The following Pre	p Methods were pe	erformed:								
Method	Description	n		A	Analyst	Date	Time	Prep Batc	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1415	1265153		
The following Ar	nalytical Methods v	were perfo	rmed:							
Method	Description			**************************************		Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							

JEhristopher 4/5/13

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# **Certificate of Analysis**

Project:

Client ID:

ECOL00724

ECOL007

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-13-30

Sample ID:

315573043

Matrix:

Soil

Collect Date:

16-NOV-12 14:10

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	Solid "Dry Weight	Corrected <sup>1</sup>	1							
Radium-226		0.896	+/-0.197	0.169	1.00	pCi/g	M	XR1 12/12/12	1320 1265273	1
The following Pre	ep Methods were pe	erformed:								
Method	Description	n		Α	nalyst	Date	Time	Prep Batcl	n	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	D	RS1	11/20/12	1415	1265153		
The following Ar	nalytical Methods v	vere perfo	rmed:							
Method	Description			·		Ana	alvst Comr	nents		
1	DOE HASL 3	00. 4.5.2.3/0	ia-01-R	//			,			

J3Christopher 4/5/13

Project:

Client ID:

ECOL00724

ECOL007

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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-15-1

315573044

Sample ID: Matrix:

Collect Date:

Soil 16-NOV-12 14:20

Receive Date: Collector:

20-NOV-12 Client

DOE HASL 300, 4.5.2.3/Ga-01-R

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis				11 11 1111 = 111					
Gamma, Ra226, S	olid "Dry Weight	Corrected"								
Radium-226		18.3	+/-0.624	0.267	1.00	pCi/g	M	XR1 12/12/12	1320 1265273	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		F	Analyst	Date	Time	Prep Batch	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Γ	DRS1	11/20/12	1415	1265153		
The following An	nalytical Methods v	vere perfoi	med:	1						
Method	Description					Ana	alyst Comn	nents		

3 Christopher 4/5/13

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Project:

Client ID:

ECOL00724

ECOL007

### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-15-2

315573045

Sample ID: Matrix:

Soil

Collect Date:

16-NOV-12 14:23

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst	Date	Time	Batch	Method
Rad Gamma Spec	Analysis											
Gamma, Ra226, S	Solid "Dry Weight	Corrected <sup>1</sup>	ı									-
Radium-226	, ,	5.69	+/-0.343	0.168	1.00	pCi/g	M	XR1 12	2/12/12	1320 1	265273	1
The following Pre	p Methods were pe	erformed:										
Method	Description	1		1	Analyst	Date	Time	Prep	Batch	1		
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1415	1265	153			
The following Ar	nalytical Methods v	vere perfo	rmed:									
Method	Description			,		An	alyst Comn	nents				
1	DOE HASL 3	00, 4.5.2.3/0	a-01-R									

Ahristopher 4/5/13

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Project:

Client ID:

ECOL00724

ECOL007

# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-15-3

315573046

Sample ID:

Matrix:

Soil

Collect Date:

16-NOV-12 14:25

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Ar	nalyst Date	Time Batch	Method
Rad Gamma Spec	Analysis					111111111111111111111111111111111111111				
Gamma, Ra226, S	Solid "Dry Weight	Corrected	ri .							
Radium-226		3.30	+/-0.228	0.152	1.00	pCi/g	M	XR1 12/12/12	1321 1265273	1
The following Pre	ep Methods were p	erformed:								
Method	Description	n		A	nalyst	Date	Time	Prep Batcl	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	A-021	D	RS1	11/20/12	1415	1265153		
The following Ar	nalytical Methods v	were perfo	rmed:							
Method	Description	1				Ana	alyst Comn	nents		
1	DOE HASL 3	300, 4.5.2.3/0	Ga-01-R							

23 Christopher 4/5/13

Project:

Client ID:

ECOL00724 ECOL007

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# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact: Project:

Ms. Mindy Song

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-16-1

Sample ID:

315573047

Matrix:

Soil

Collect Date:

16-NOV-12 14:45

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Batcl	n Method
Rad Gamma Spec	Analysis		·							
Gamma, Ra226, S	olid "Dry Weight	Corrected	t							
Radium-226		5.42	+/-0.332	0.157	1.00	pCi/g	M	XR1 12/12/12	1321 1265273	1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		1	Analyst	Date	Time	Prep Batcl	1	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	I	DRS1	11/20/12	1415	1265153		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R							



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### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

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Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-16-2

Project:

ECOL00724

Sample ID:

Client ID:

ECOL007

315573048

Matrix:

Soil

Collect Date:

16-NOV-12 14:48

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF At	nalyst Date	Time Batch l	Method
Rad Gamma Spec	Analysis								•	
Gamma, Ra226, S	olid "Dry Weight	Corrected	"							
Radium-226		6.09	+/-0.357	0.189	1.00	pCi/g	M	XR1 12/12/12	1321 1265273	1
The following Pre	p Methods were pe	erformed:							•	
Method	Description	n		P	Analyst	Date	Time	Prep Batch	h	
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	x-021	Γ	RS1	11/20/12	1415	1265153		
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description					Ana	alyst Comn	nents		
1	DOE HASL 3	00, 4.5.2.3/0	Ga-01-R				••••			

Bhristopher 4/5/13

Project:

Client ID:

ECOL00724

ECOL007

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

# **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID:

AUM-32-RA-16-3

Sample ID:

315573049

Matrix:

Soil

Collect Date:

16-NOV-12 14:50

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF Aı	nalyst Date	Time Ba	tch Method
Rad Gamma Spec	Analysis									
Gamma, Ra226, S	olid "Dry Weight	Corrected <sup>1</sup>	1							
Radium-226		3.44	+/-0.329	0.189	1.00	pCi/g	M	IXR1 12/13/12	2 0805 12652	73 1
The following Pre	p Methods were pe	erformed:								
Method	Description	1		A	Analyst	Date	Time	Prep Bate	h	***************************************
Dry Soil Prep	Dry Soil Prep	GL-RAD-A	-021	Ε	RS1	11/20/12	1415	1265153	12 10 400	
The following An	alytical Methods v	vere perfo	rmed:							
Method	Description			***************************************		Ana	alyst Comn	nents		***************************************
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98 Christophu 4/5/13

2040 Savage Road Charleston SC 29407 - (843) 556-8171 - www.gel.com

### **Certificate of Analysis**

Report Date: December 14, 2012

Company:

Ecology & Environment, Inc.

Address:

3700 Industry Ave.

#102

Lakewood, California 90712

Contact:

Ms. Mindy Song

Project:

2693.2200.06TTO Tronox AUM Sections 32 & 33 Removal Action

Client Sample ID: AUM-32-RA-16-30

Project:

ECOL00724

Sample ID:

315573050

Client ID:

ECOL007

Matrix:

Soil

Collect Date:

16-NOV-12 14:51

Receive Date:

20-NOV-12

Collector:

Client

Parameter	Qualifier	Result	Uncertainty	DL	RL	Units	DF A	nalyst Date	Time Batch I	Method
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Gamma, Ra226, S	Solid "Dry Weight	Corrected'	•							
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The following Pre	p Methods were pe	erformed:								
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3 Christopher 4/5/13

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	YELLOW = FILE PINK = CLIFNT	<ol> <li>Sample Analysis Requested: Analytical method requested (i.e. 8260B) t</li> <li>Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = So</li> </ol>	6010B/1470A) and number of containers provided for each (i.e. 8260B odium Hydroxide, SA = Sulfuric Acid: AA = Ascorbic Acid HX = Have	1-3, 6010B/7470A - 1).	

Page: A of S		1						GFI Laboratories 11 C	
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GEL Cuote #:			•			•	<b>.</b>	Charleston, SC 29407	
COC Number: GEL	GEL Work Order Number:	ıber:						Phone: (843) 556-8171	
Client Name:		Phone #:				Sam	Sample Analysis Requested <sup>(5)</sup> (F	(Fill in the number of containers for each test)	s for each test)
Project/Site Name: Tronox Sort. 32/23 (Sentand) Fax #:	23 Rowand	Fax #:			Should this				< Preservative Type (6)
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Sample ID • For composites - indicate start and stop date/time	*Date Collected (mm-dd-yy)	•Time Collected QC (Military)	QC Code Field  Piltered (1)	Sample Matrix (4)	Sadionetive TSCA Regula	dmun lato)	<i>لاء</i> -ع		required for sample specific QC
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3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered. 4.) Matrix Codes: DW-Drinking Water, GW-Groundwater, SW-Surface Water, WW-Water, W-Water, W-Water, SD-Stediment, SL-Sludge, SS-Solid Waste, O-Oil, F-Filter, P-Wize, U-Lyine, F-Feeal, N-Nassa	ple was field filtered or - N - Water, WW=Waste Water,	for sample was no W=Water, SO=Soi	t field filtered. I. SD=Sediment, S	L≖Sludge, S	S=Solid W	ste, O=Oi	. F=Filter. P=Wipe. U=Urine. F=Fecal. N		Custody Seal Intact?
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B, 6010B/7470A - 1).	6010B/7470A) and number	of containers provid	ded for each (i.e. 8	2608 - 3, 60	10B/7470A	<del>-</del>			oler Tem
o.) Preservative 1998: n.a. = hydrocanone Acid, N. = Nitre Acid, S. H. = Sulfure Acid, A.A. = Ascorbic Acid, H.X. = Hexare, S.T. = Sodium Thiosulfate, If no preservative is added = leave field blank WHITE = LABORATORY YELLOW = FILE PINK = CLIENT	ORATORY	unic Acid; AA = As YE	= Ascorbic Acid, HX = He YELLOW = FILE	Hexane, ST JE	= Sodium	Thiosulfate PINI	iosulfate, If no preservative is added = leave field I PINK = CLIENT	Siank	0

Page: 3 of 5										
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					, ( , , , ,	nhar mar		Charleston SC 29407	201	
i. 0.	GEL Work Order Number:							Phone: (843) 556-8171	171	
								Fax: (843) 766-1178	œ	
Client Name:	ā.	Phone #:			Saı	Sample Analysis Requested (5)		in the number of c	(Fill in the number of containers for each test)	£
Project/Site Name: Troyox Sect. 32/23 Reword	9	Fax #:		Should this	ļ				< Preservative Type (6)	(e Tvpe (6)
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1.) Chain of Custody Number = Client Determined 2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Matrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite	i = Equipment Blank, MS	= Matrix Spike Sam	ple, MSD = Matrix Sp	ike Duplicate	Sample, C	= Grab, C = Composite			For Lab Receiving Use Only	Use Only
3.) Field Filtered: For liquid matrices, indicate with a - Y - for yes the sample was field filtered or - N - for sample was not field filtered. 4.) Matrix Codes: DW=Drinking Water, GW=Groundwater, SW=Surfacq Water, WW=Water, W=Water, SD=Sodiment, SL=Sludge, SS=Solid Waste, O=Oil, F=Filter, P=Wipe, U=Urine, F=Fecal, N=Nassal	as field filtered or - N - for r, WW=Waste Water, W=	sample was not field Water, SO=Soil, SD:	1 filtered. =Sediment, SL=Sludg	e, SS=Solid	Naste, O=(	)il, F=Filter, P=Wipe, U≖	Urine, F=Fecal, N=]	lessa.	Custody Seal Intact?	tact?
5.) Sample Analysis Requested: Analytical method requested (i.e. 8260B   6010B/7470A ) and number of containers provided for each (i.e. 8260B - 3, 6010B/7470A - 1). 6.) Preservative Type: HA = Hydrochloric Acid, SN = Nitric Acid, SN = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfare If no preservative is added = Ireave first hank	3/7470A) and number of c Hydroxide, SA = Sulfuric	ontainers provided for Acid; AA = Ascorbi	or each (i.e. 8260B	. 6010B/7470	74 - 1). n Thiosulf	ite. If no preservative is ad	hed = leave field bis	<u> </u>	Cooler Temp:	ä
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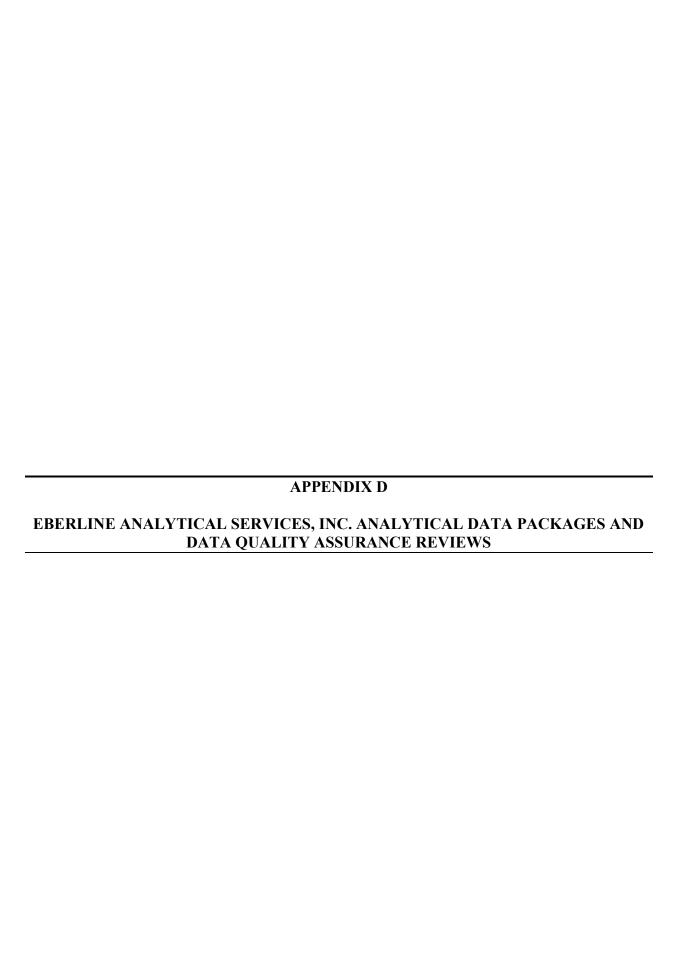
Page: 4 of 5		1							GEL 1 aboratories 11 C	0 1 1	
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(1).						•		•	Charleston, SC 29407	9407	
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Client Name:		Phone #:				Sam	ple Analysi	Sample Analysis Requested (5)	Fill in the number of	(Fill in the number of containers for each test)	
Project/Site Name: Tronox Sect. 33/33	Removal	Fax #:			Should this	<u></u>				< Preservative Type (6)	(ype (6)
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5.) Sample Analysis Requested: Analytical method requested (i.e. 82608| 601087470A) and number of containers provided for each (i.e. 82608 - 3, 6010B7470A - 1).
6.) Preservative Type: HA = Hydrochloric Acid, NI = Nitric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank
WHITE = LABORATORY
YELLOW = FILE
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Page: <b>5</b> of <b>5</b> Project #:	GEI, Ch	ain of Cu	stody an	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	1	GEL Chain of Custody and Analytical Doguest	GEL Laboratories, LLC	
GEL Quote #:			The Carone		ary cr	cai nequest	Charleston, SC 29407	
COC Number: PO Number:	GEL Work Order Number:	ıber:					Phone: (843) 556-8171	
Client Name:		Phone #:			Sam	Sample Analysis Requested <sup>(5)</sup> (Fi	(Fill in the number of containers for each test)	iners for each test)
Project/Site Name: Troyox 5x1.33/33 Removal	Removal	Fax #:		Should this	L			< Preservative Type (6)
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Remarks: Are there any known hazards applicable to these samples? If so, please list the hazards	ble to these samples	? If so, please list	the hazards			l		1
Chain of C	Chain of Custody Signatures					Sample Shim	Samule Shinning and Delivery Defails	
Relinquished By (Signed) Date Time	Received by (signed)	gned) Date	Time	B	GEL PM:			
1 Cong 2 lallo- 11/17/13 1000		1-20-12	-12 6910		Method of Shipment:	pment:	Date Shipped:	
2	2 0 0			Airt	Airbill#:			
3	3			Air	Airbill#:			
1.) Chain of Custody Number = Client Determined 2.) QC Codes: N = Normal Sample, TB = Trip Blank, FD = Field Duplicate, EB = Equipment Blank, MS = Marrix Spike Sample, MSD = Matrix Spike Duplicate Sample, G = Grab, C = Composite	ate, EB = Equipment Blank,	MS = Matrix Spike Sampl	le, MSD = Matrix Spik	e Duplicate S	ample. G=	Grab, C = Composite		For Lab Receiving Use Only
2.) First nucros, indicate with a - Y - for yes the sample was field filtered or. N - for sample was not field filtered. 4.) Matrix Codes: Development with a - Y - for yes the sample was field filtered or. N - for sample was not filtered. 4.) Matrix Codes: Development with water, Benefit was the control of the property of the proper	mple was field filtered or - N - C Water, WW=Waste Water,	for sample was not field  W=Water, SO=Soil, SD=	filtered. Sediment, SL=Sludge,	W PiloS=SS	sste, O=Oil	, F=Filter, P=Wipe, U=Urine, F=Fecal, N	=Nasal	Custody Seal Intact? YES NO
6) Preservative Type: HA = Hydrochloric Acid, SH = Sodium Hydroxide, SA = Sulfuric Acid, AA = Ascorbic Acid, HX = Hexane, ST = Sodium Thiosulfate, If no preservative is added = leave field blank	Sodium Hydroxide, SA = Sulf	or containers provided for uric Acid; AA = Ascorbic	Acid, HX = Hexane, S	T = Sodium	- 1). Thìosulfate	. If no preservative is added = leave field b	olank	Cooler Temp:
WHITE = LABORATORY	BORATORY	YELLO	YELLOW = FILE		PIN	PINK = CLIENT		

# SAMPLE RECEIPT & REVIEW FORM

C	lient: E(OL			SI	OG/AR/COC/Work Order: 3/5573
R	eceived By: JP			Da	nte Received: 11-20-12
S	uspected Hazard Information	Yes	ž	*If inv	Net Counts > 100cpm on samples not marked "radioactive", contact the Radiation Safety Group for further vestigation.
	OC/Samples marked as radioactive?				aximum Net Counts Observed* (Observed Counts - Area Background Counts): Ocom
_	lassified Radioactive II or III by RSO?	_	/	If y	yes, Were swipes taken of sample containers < action levels?
	OC/Samples marked containing PCBs? ackage, COC, and/or Samples marked as	<del> </del>	/	_	
	eryllium or asbestos containing?	]	1/	l If v	ves, samples are to be segregated as Safety Controlled Samples, and opened by the GEL Safety Group.
	nipped as a DOT Hazardous?	1		Ha	zard Class Shipped:  UN#:
Sa	imples identified as Foreign Soil?				
	Sample Receipt Criteria	Yes	NA A	ž	
	Shipping containers received intact and sealed?				Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
2	Samples requiring cold preservation within (0 ≤ 6 deg. C)?*				Preservation Method: Ice bags Blue ice Dry ice (None) Other (describe) *all temperatures are recorded in Celsius
2	Daily check performed and passed on IR temperature gun?				Temperature Device Serial #: (1150) 700 Cl Secondary Temperature Device Serial # (If Applicable):
3	Chain of custody documents included with shipment?	/			
4	Sample containers intact and sealed?				Circle Applicable: Seals broken Damaged container Leaking container Other (describe)
5	Samples requiring chemical preservation at proper pH?				Sample ID's, containers affected and observed pH:  If Preservation added, Lot#:
6	VOA vials free of headspace (defined as < 6mm bubble)?		$\overline{}$		Sample ID's and containers affected:
7	Are Encore containers present?			_	(If yes, immediately deliver to Volatiles laboratory)
8	Samples received within holding time?			***************************************	ID's and tests affected:
9	Sample ID's on COC match ID's on bottles?				Sample ID's and containers affected:
10	Date & time on COC match date & time on bottles?		,	***************************************	Sample ID's affected:
11	Number of containers received match number indicated on COC?				Sample ID's affected:
12	Are sample containers identifiable as GEL provided?				
13	COC form is properly signed in relinquished/received sections?				
	Carrier and tracking number.				Circle Applicable: FedEx Air FedEx Ground UPS Field Services Courier Other  7941 (2037 8939 11 11 9199
Con	nments (Use Continuation Form if needed):	zy	)/	フ	Schristopher 4/5/13
	PM (or PM A) rev		r 1.1		OP Date 11-20-12 Page 1-6 1



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					Report To:					Nork Order Det	ails:		
Fbe	rline	<b>Analytical</b>	Jeff Wri					SDG:	18-0				
		_	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Fina	al Repo	ort of Analysis	13702 C	oursey E	lvd, Bld	7 Suite	• <b>A</b>	Analysis Category:	ENVIR	CONMENT	AL		
	-		Baton R	ouge, LA	70817-1	370		Sample Matrix:	SO				
LabID	SampleTy pe	ClientID	SampleDate	ReceiptDat e	AnalysisDa te	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
18-06117-01	LCS	KNOWN	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Cobalt-60	EPA 901.1 Modified	1.37E+02	5.48E+00			pCi/g
18-06117-01	LCS	KNOWN	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Cesium-137	EPA 901.1 Modified	8.69E+01	3.48E+00			pCi/g
18-06117-01	LCS	SPIKE	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Cobalt-60	EPA 901.1 Modified	1.26E+02	7.63E+00	1.00E+01	1.53E+00	pCi/g
18-06117-01	LCS	SPIKE	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Cesium-137	EPA 901.1 Modified	8.00E+01	7.01E+00	8.13E+00	1.33E+00	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Actinium-228	EPA 901.1 Modified	2.44E-02	9.19E-02	9.19E-02	1.52E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Bismuth-214	EPA 901.1 Modified	6.89E-02	4.32E-02	4.33E-02	1.42E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Potassium-40	EPA 901.1 Modified	9.46E-02	2.02E-01	2.02E-01	4.24E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	-2.21E+00	2.85E+00	2.85E+00	4.00E+00	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Lead-212	EPA 901.1 Modified	5.87E-02	4.97E-02	4.98E-02	8.27E-02	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Lead-214	EPA 901.1 Modified	-8.36E-03	2.25E-02	2.25E-02	1.04E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Radium-226	EPA 901.1 Modified	6.89E-02	4.32E-02	4.33E-02	1.42E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Thorium-234	EPA 901.1 Modified	-1.37E-01	1.61E-01	1.61E-01	7.78E-01	pCi/g
18-06117-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06117	Thallium-208	EPA 901.1 Modified	4.86E-02	7.82E-02	7.83E-02	1.40E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.29E+00	2.51E-01	2.60E-01	4.56E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.08E+00	1.96E-01	2.04E-01	2.42E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	2.13E+01	2.56E+00	2.78E+00	1.26E+00	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	-2.83E+00	6.04E+00	6.04E+00	8.22E+00	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.36E+00	2.21E-01	2.32E-01	2.91E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.36E+00	1.97E-01	2.09E-01	2.41E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.08E+00	1.96E-01	2.04E-01	2.42E-01	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	3.39E+00	1.39E+00	1.40E+00	2.21E+00	pCi/g
18-06117-03	DUP	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.27E+00	2.06E-01	2.16E-01	1.79E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.28E+00	2.49E-01	2.57E-01	4.27E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.26E+00	1.78E-01	1.89E-01	2.04E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	2.10E+01	2.55E+00	2.77E+00	1.39E+00	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	1.84E+00	5.43E+00	5.43E+00	8.70E+00	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.39E+00	2.30E-01	2.41E-01	3.25E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.11E+00	1.95E-01	2.03E-01	2.23E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.26E+00	1.78E-01	1.89E-01	2.04E-01	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	3.12E+00	2.17E+00	2.18E+00	3.59E+00	pCi/g
18-06117-04	DO	33-11-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.13E+00	1.75E-01	1.85E-01	1.62E-01	pCi/g
18-06117-05	TRG	33-11-62-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.20E+00	2.86E-01	2.92E-01	4.01E-01	pCi/g

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Eberline Analytical Final Report of Analysis  Jeff Wright Weston Solutions, Inc. 13702 Coursey Blvd,			SDG:	18-06	6117			<u>i</u>
vveston solutions, in								
Final Report of Analysis 13702 Coursey Blvd.	DI-I 7 014		Purchase Order:	009513	31			
	Blaa / Sult	e A	Analysis Category:	ENVIR	ONMENT	AL		
Baton Rouge, LA 708		_	Sample Matrix:	SO				
LabID SampleTy ClientID SampleDate ReceiptDat Analy	sisDa BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
pe Cilettib SampleDate e te	Batchib	Analyte	Wethou	Result		030	IVIDA	Reportonits
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Bismuth-214	EPA 901.1 Modified	1.22E+00	1.99E-01	2.08E-01	2.50E-01	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Potassium-40	EPA 901.1 Modified	2.02E+01	2.50E+00	2.71E+00	1.38E+00	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Protactinium-234m	EPA 901.1 Modified	-3.73E+00	6.21E+00	6.21E+00	8.74E+00	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/.	2018 18-06117	Lead-212	EPA 901.1 Modified	1.51E+00	2.71E-01	2.82E-01	2.44E-01	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Lead-214	EPA 901.1 Modified	1.38E+00	2.30E-01	2.41E-01	2.49E-01	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Radium-226	EPA 901.1 Modified	1.22E+00	1.99E-01	2.08E-01	2.50E-01	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thorium-234	EPA 901.1 Modified	8.15E-01	9.96E-01	9.96E-01	1.67E+00	pCi/g
18-06117-05 TRG 33-11-62-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thallium-208	EPA 901.1 Modified	1.12E+00	2.00E-01	2.08E-01	1.75E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Actinium-228	EPA 901.1 Modified	1.92E+00	3.67E-01	3.80E-01	4.50E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Bismuth-214	EPA 901.1 Modified	1.31E+00	2.58E-01	2.67E-01	4.46E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Potassium-40	EPA 901.1 Modified	2.14E+01	2.81E+00	3.02E+00	1.24E+00	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Protactinium-234m	EPA 901.1 Modified	-5.93E-01	8.38E+00	8.38E+00	1.36E+01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Lead-212	EPA 901.1 Modified	1.92E+00	3.40E-01	3.54E-01	3.39E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Lead-214	EPA 901.1 Modified	1.64E+00	2.58E-01	2.71E-01	3.32E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Radium-226	EPA 901.1 Modified	1.31E+00	2.58E-01	2.67E-01	4.46E-01	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thorium-234	EPA 901.1 Modified	5.81E+00	2.97E+00	2.98E+00	9.16E+00	pCi/g
18-06117-06 TRG 33-12-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thallium-208	EPA 901.1 Modified	1.58E+00	3.42E-01	3.51E-01	4.43E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Actinium-228	EPA 901.1 Modified	1.63E+00	3.97E-01	4.06E-01	7.76E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Bismuth-214	EPA 901.1 Modified	1.37E+00	2.48E-01	2.57E-01	3.01E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Potassium-40	EPA 901.1 Modified	1.98E+01	3.10E+00	3.26E+00	2.39E+00	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Protactinium-234m	EPA 901.1 Modified	5.06E+00	1.02E+01	1.02E+01	1.77E+01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Lead-212	EPA 901.1 Modified	1.65E+00	3.11E-01	3.22E-01	3.21E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Lead-214	EPA 901.1 Modified	1.20E+00	3.03E-01	3.09E-01	4.32E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Radium-226	EPA 901.1 Modified	1.37E+00	2.48E-01	2.57E-01	3.01E-01	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thorium-234	EPA 901.1 Modified	1.00E+00	1.55E+00	1.56E+00	2.30E+00	pCi/g
18-06117-07 TRG 33-13-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Thallium-208	EPA 901.1 Modified	1.17E+00	2.81E-01	2.87E-01	3.95E-01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Actinium-228	EPA 901.1 Modified	1.40E+00	2.50E-01	2.60E-01	5.13E-01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/	2018 18-06117	Bismuth-214	EPA 901.1 Modified	1.44E+00	2.02E-01	2.15E-01	2.27E-01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/		Potassium-40	EPA 901.1 Modified	2.22E+01	2.60E+00	2.84E+00	1.05E+00	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/		Protactinium-234m	EPA 901.1 Modified	4.44E+00	6.07E+00	6.08E+00	1.01E+01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/		Lead-212	EPA 901.1 Modified	1.53E+00	2.46E-01	2.58E-01	2.81E-01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/		Lead-214	EPA 901.1 Modified	1.37E+00	2.29E-01	2.40E-01	2.71E-01	pCi/g
18-06117-08 TRG 33-14-61-180620 06/20/18 00:00 6/26/2018 7/19/		Radium-226	EPA 901.1 Modified	1.44E+00	2.02E-01	2.15E-01	2.27E-01	pCi/g

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					Report To:				l	Vork Order Det	ails:		
Fho	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-0	6117			
		_	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
l Fina	l Rep	ort of Analysis	13702 C	oursey E	Blvd. Bld	a 7 Suite	A	Analysis Category:	ENVIR	ONMENT	AL		
	•			ouge, LA				Sample Matrix:	SO				
LabID	SampleTy	ClientID			AnalysisDa	BatchID	Amalusta	Method	Decult	CU	CSU	MDA	Donorti Inito
Labib	pe	Clientib	SampleDate	е	te	Бакспір	Analyte	Wethod	Result	CU	CSU	IVIDA	ReportUnits
18-06117-08	TRG	33-14-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	2.62E+00	2.04E+00	2.05E+00	3.39E+00	pCi/g
18-06117-08	TRG	33-14-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.26E+00	1.98E-01	2.08E-01	1.99E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.50E+00	2.97E-01	3.07E-01	4.63E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.34E+00	2.15E-01	2.25E-01	2.10E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	2.19E+01	2.72E+00	2.94E+00	1.37E+00	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	5.45E+00	6.33E+00	6.34E+00	1.10E+01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.62E+00	2.63E-01	2.76E-01	3.13E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.48E+00	2.39E-01	2.51E-01	2.86E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.34E+00	2.15E-01	2.25E-01	2.10E-01	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	1.65E+00	1.69E+00	1.69E+00	2.82E+00	pCi/g
18-06117-09	TRG	33-15-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.32E+00	2.26E-01	2.36E-01	2.00E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.89E+00	3.44E-01	3.58E-01	6.07E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.14E+00	3.26E-01	3.31E-01	6.23E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	1.96E+01	2.58E+00	2.77E+00	7.24E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	-1.30E+00	7.78E+00	7.78E+00	1.26E+01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.72E+00	3.06E-01	3.18E-01	2.98E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	2.03E+00	3.07E-01	3.24E-01	8.21E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.14E+00	3.26E-01	3.31E-01	6.23E-01	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	-1.50E+01	2.57E+00	2.68E+00	2.93E+00	pCi/g
18-06117-10	TRG	33-16-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	9.87E-01	2.60E-01	2.65E-01	3.15E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.64E+00	3.88E-01	3.97E-01	8.36E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.22E+00	2.55E-01	2.62E-01	3.96E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	1.90E+01	2.71E+00	2.88E+00	1.19E+00	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	7.96E-01	9.63E+00	9.63E+00	1.58E+01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.58E+00	3.27E-01	3.37E-01	3.41E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.38E+00	2.47E-01	2.57E-01	6.90E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.22E+00	2.55E-01	2.62E-01	3.96E-01	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	1.28E+00	1.51E+00	1.51E+00	2.52E+00	pCi/g
18-06117-11	TRG	33-17-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.19E+00	2.96E-01	3.02E-01	3.02E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.53E+00	2.78E-01	2.89E-01	4.45E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.29E+00	1.89E-01	2.00E-01	2.11E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	2.00E+01	2.50E+00	2.70E+00	1.31E+00	pCi/g

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					Report To:					Work Order Det	ails:		
Fhe	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-0	6117			
		_	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Fina	ıl Rep	ort of Analysis	13702 C	oursey E	lvd, Bld	g 7 Suite	A	Analysis Category:	ENVIR	RONMENT	AL		
	•	,		ouge, LA				Sample Matrix:	SO				
LabID	SampleTy pe	ClientID	SampleDate	<del></del>	AnalysisDa te	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	7.85E-01	6.33E+00	6.33E+00	9.98E+00	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.92E+00	3.28E-01	3.43E-01	2.46E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.25E+00	2.11E-01	2.21E-01	2.52E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.29E+00	1.89E-01	2.00E-01	2.11E-01	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	1.70E+00	1.55E+00	1.55E+00	2.58E+00	pCi/g
18-06117-12	TRG	33-18-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.04E+00	1.94E-01	2.01E-01	1.73E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.38E+00	2.83E-01	2.92E-01	7.14E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.17E+00	2.33E-01	2.41E-01	2.86E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	1.91E+01	2.59E+00	2.77E+00	1.29E+00	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	5.97E+00	7.94E+00	7.95E+00	1.39E+01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.80E+00	3.43E-01	3.55E-01	3.81E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.26E+00	2.90E-01	2.97E-01	5.01E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.17E+00	2.33E-01	2.41E-01	2.86E-01	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	7.76E+00	2.02E+00	2.06E+00	8.58E+00	pCi/g
18-06117-13	TRG	33-19-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.11E+00	3.83E-01	3.87E-01	5.60E-01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Actinium-228	EPA 901.1 Modified	1.03E+00	3.65E-01	3.69E-01	1.18E+00	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Bismuth-214	EPA 901.1 Modified	1.02E+00	2.56E-01	2.61E-01	3.70E-01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Potassium-40	EPA 901.1 Modified	2.03E+01	2.85E+00	3.03E+00	1.40E+00	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Protactinium-234m	EPA 901.1 Modified	7.33E+00	8.52E+00	8.53E+00	1.55E+01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-212	EPA 901.1 Modified	1.26E+00	2.46E-01	2.55E-01	6.44E-01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Lead-214	EPA 901.1 Modified	1.17E+00	2.55E-01	2.62E-01	4.07E-01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Radium-226	EPA 901.1 Modified	1.02E+00	2.56E-01	2.61E-01	3.70E-01	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thorium-234	EPA 901.1 Modified	2.49E+00	1.61E+00	1.62E+00	2.65E+00	pCi/g
18-06117-14	TRG	33-20-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06117	Thallium-208	EPA 901.1 Modified	1.19E+00	2.48E-01	2.55E-01	6.50E-02	pCi/g

**MEMO** 

DATE: June 27, 2019

TO: Keith Delhomme, Robert Sherman

FROM: Rick Haaker RF Hawher

SUBJECT: Review of Gamma Spectroscopy Data Package, 18-06117

The file evaluated was SEC33\_1806117.xls.

This package consisted of 11 soil samples (1 of which was a replicate count that was analyzed twice for a total of 12 results), plus method blanks, lab control standards/spikes. All concentration units are in units of pCi/g, unless otherwise noted. The results are considered acceptable for use, except where noted otherwise. The following samples were analyzed by gamma spectroscopy.

Sar	SampleID_Table											
ClientID	LabID	Sample Type										
33-11-61-180620	18-06117-03	DUP										
33-11-61-180620	18-06117-04	DO										
33-11-62-180620	18-06117-05	TRG										
33-12-61-180620	18-06117-06	TRG										
33-13-61-180620	18-06117-07	TRG										
33-14-61-180620	18-06117-08	TRG										
33-15-61-180620	18-06117-09	TRG										
33-16-61-180620	18-06117-10	TRG										
33-17-61-180620	18-06117-11	TRG										
33-18-61-180620	18-06117-12	TRG										
33-19-61-180620	18-06117-13	TRG										
33-20-61-180620	18-06117-14	TRG										

The data was delivered in the usual Microsoft excel data format.

No isotopes were detected in the method blank samples at levels that exceeded the minimum detectable activity. Detected activity in the blanks is not a good thing.

The agreement between duplicate sample results was acceptable.

Thorium-234 results were considerably more precise than protactinium-234m results. The protactinium-234m results should not by themselves be considered reliable. Th-234 was reported as present at levels that exceed the minimum detectable activity in samples as follows. Results are in the units of pCi/g.

Detected Th234									
ClientID Analyte Results MDAG									
33-11-61-180620	Thorium-234	3.39	2.21						

Ignoring protactinium-234m, all other uranium decay chain analytes were detected in all samples except as follows:

NonDetects										
ClientID	Analyte	Result	MDAC	ReportUnits						
33-11-62-180620	Thorium-234	0.82	1.6685	pCi/g						
33-12-61-180620	Thorium-234	5.81	9.1553	pCi/g						
33-13-61-180620	Thorium-234	1	2.3043	pCi/g						
33-14-61-180620	Thorium-234	2.62	3.3902	pCi/g						
33-15-61-180620	Thorium-234	1.65	2.8167	pCi/g						
33-16-61-180620	Thorium-234	-14.99	2.9313	pCi/g						
33-17-61-180620	Thorium-234	1.28	2.5241	pCi/g						
33-18-61-180620	Thorium-234	1.7	2.5776	pCi/g						
33-19-61-180620	Thorium-234	7.76	8.5762	pCi/g						
33-20-61-180620	Thorium-234	2.49	2.6514	pCi/g						

This Eberline data package reports radium-226 as equal to bismuth-214, the radium-226 being assigned from the bismuth-214 values. Radium-226 concentrations ranged up to 2 pCi/g.

The degree of agreement between thorium-234 and radium-226 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that the thorium-234 results might be seriously biased by systematic error. The test statistic is the number of standard deviations by which the thorium-234 result exceeds the radium-226 result. If the test statistic is substantially less than zero, it implies that the reported radium-226 concentration is greater than the thorium-234 concentration. Gamma spectroscopy cannot detect thorium-230, so agreement between thorium-234 and radium-226 doesn't provide any information about equilibrium between thorium-230 and radium-226.

Equilibrium: Th234 → Ra-226										
ClientID	Test Sta- tistic	Disequilibrium Evidence								
33-11-61-180620	3.28	Strong								
33-11-61-180620	1.7	Weak or none								
33-11-62-180620	-0.79	Weak or none								
33-12-61-180620	3	Strong								

Equilibrium: Th234 → Ra-226										
ClientID	Test Sta- tistic	Disequilibrium Evidence								
33-13-61-180620	-0.46	Weak or none								
33-14-61-180620	1.14	Weak or none								
33-15-61-180620	0.36	Weak or none								
33-16-61-180620	-11.94	Strong								
33-17-61-180620	0.08	Weak or none								
33-18-61-180620	0.52	Weak or none								
33-19-61-180620	6.36	Strong								
33-20-61-180620	1.79	Weak or none								

The degree of agreement between radium-226 and lead-210 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that there is no proficiency testing of radiochemistry laboratories for isotopes having gamma energies similar to those for lead-210. The test statistic is the number of standard deviations by which the radium-226 result exceeds the lead-210 result. If the test statistic is substantially less than zero, it implies that the reported lead-210 concentration is greater than the radium-226 concentration. Agreement between radium-226 and lead-210 doesn't provide *any* information about equilibrium between thorium-230 and radium-226.

No Lead-210 results were reported for this data package.

Twenty-three days elapsed from the date of receipt by Eberline to the date of analysis in their laboratory, which is good. At least twenty-one days normally occurs between sealing and counting.

My impression is that the laboratory analyses are acceptable for use.

The maximum and estimated 99%UCLs (assuming normal statistics) for nuisance radionuclides in pCi/g, based on all prior datasets reviewed to this point are:

Analyte	Maximum	UCL99%
Actinium-228	2.19	2.12
Lead-212	8.45	3.29
Potassium-40	28.22	32.28
Thallium-208	2.12	1.95

For this dataset (data package), the following matrix of linear correlation coefficients was obtained for samples having a radium-226 concentration below 10pCi/g. Correlation coefficients can have a range between 1 and -1, and are a measure of tendency of pairs of *reported* isotopic concentrations to go up and down together in a

18-06117

linear fashion. These correlation coefficients are based on observations in the concentration range of interest to project engineers.

	Ac_228	Bi _214	Pb_212	Pb_214	K_40	Pa_234m	Ra_226	TI _208	Th_234
Ac_228	1.00	0.38	0. 75	0. 71	-0. 12	-0. 25	0. 38	0. 22	-0.41
Bi _214	0. 38	1.00	0.42	-0.03	0.41	0. 16	1.00	0. 28	0. 15
Pb_212	0. 75	0.42	1.00	0. 39	-0. 23	-0. 10	0.42	0.09	-0.04
Pb_214	0. 71	-0.03	0. 39	1.00	0.00	-0.43	-0.03	0.06	-0. 73
K_40	-0. 12	0.41	-0. 23	0.00	1.00	0.03	0.41	0.60	0. 22
Pa_234m	-0. 25	0. 16	-0. 10	-0.43	0.03	1. 00	0. 16	0.02	0. 31
Ra_226	0. 38	1.00	0.42	-0.03	0.41	0. 16	1.00	0. 28	0. 15
TI _208	0. 22	0. 28	0.09	0.06	0.60	0. 02	0. 28	1.00	0. 51
Th 234	-0.41	0. 15	-0.04	-0. 73	0. 22	0. 31	0. 15	0. 51	1.00

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					Report To:			Work Order Details:					
Fha	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-0	6116-Re	evised		
		_	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Fina	ıl Rep	ort of Analysis	13702 C	oursey E	Blvd, Bld	g 7 Suite	• <b>A</b>	Analysis Category:	ENVIR	CONMENT	AL		
	•	•	Baton R	louge, LA	70817-1	1370		Sample Matrix:	SO				
LabID	SampleTy pe	ClientID	SampleDate	ReceiptDat e	AnalysisDa te	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
18-06116-01	LCS	KNOWN	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Cobalt-60	EPA 901.1 Modified	1.37E+02	5.48E+00			pCi/g
18-06116-01	LCS	KNOWN	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Cesium-137	EPA 901.1 Modified	8.69E+01	3.48E+00			pCi/g
18-06116-01	LCS	SPIKE	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Cobalt-60	EPA 901.1 Modified	1.28E+02	7.69E+00	1.01E+01	1.33E+00	pCi/g
18-06116-01	LCS	SPIKE	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Cesium-137	EPA 901.1 Modified	7.98E+01	7.00E+00	8.11E+00	1.41E+00	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Actinium-228	EPA 901.1 Modified	3.09E-02	8.65E-02	8.66E-02	1.55E-01	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Bismuth-214	EPA 901.1 Modified	-4.21E-02	6.54E-02	6.55E-02	9.71E-02	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Potassium-40	EPA 901.1 Modified	8.02E-02	2.29E-01	2.29E-01	4.45E-01	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	-3.45E-01	1.85E+00	1.85E+00	2.65E+00	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Lead-212	EPA 901.1 Modified	1.63E-02	4.63E-02	4.64E-02	7.38E-02	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Lead-214	EPA 901.1 Modified	5.39E-02	6.97E-02	6.98E-02	1.14E-01	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Radium-226	EPA 901.1 Modified	-4.21E-02	6.54E-02	6.55E-02	9.71E-02	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Thorium-234	EPA 901.1 Modified	-6.70E-02	1.44E-01	1.44E-01	8.64E-01	pCi/g
18-06116-02	MBL	BLANK	06/26/18 00:00	6/26/2018	7/18/2018	18-06116	Thallium-208	EPA 901.1 Modified	2.71E-02	8.05E-02	8.05E-02	1.37E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.67E+00	4.27E-01	4.36E-01	6.08E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.28E+00	2.70E-01	2.77E-01	4.08E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.09E+01	3.14E+00	3.32E+00	2.33E+00	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	5.58E+00	1.06E+01	1.06E+01	1.80E+01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.51E+00	2.85E-01	2.96E-01	3.36E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.15E+00	2.69E-01	2.76E-01	3.13E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.28E+00	2.70E-01	2.77E-01	4.08E-01	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	5.92E-01	1.54E+00	1.54E+00	2.26E+00	pCi/g
18-06116-03	DUP	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.22E+00	2.95E-01	3.02E-01	7.02E-02	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.43E+00	3.91E-01	3.98E-01	8.09E-01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.25E+00	2.29E-01	2.38E-01	1.23E-01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.24E+01	3.19E+00	3.39E+00	1.93E+00	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	-3.43E+00	1.14E+01	1.14E+01	1.62E+01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.56E+00	3.01E-01	3.11E-01	2.65E-01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.21E+00	2.57E-01	2.64E-01	3.51E-01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.25E+00	2.29E-01	2.38E-01	1.23E-01	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	7.31E-01	1.49E+00	1.49E+00	2.20E+00	pCi/g
18-06116-04	DO	33-01-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.79E+00	4.33E-01	4.42E-01	6.93E-01	pCi/g
			00/00/	0/00:00	=/40::	40.0		==		0.55	0.00= -:	0.45= -:	
18-06116-05	TRG	33-01-62-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.32E+00	2.58E-01	2.66E-01	3.17E-01	pCi/g

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Per						Report To:			Work Order Details:					
SampleTy	Fhai	rline	Analytical	Jeff Wri	ght				SDG:	18-0	6116-Re	evised		
Baton Rouge, LA 70817-1370   Sample Matrix: SO				Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Baton Rouge, LA 70817-1370   Sample Matrix: SO	Fina	ıl Rep	ort of Analysis	13702 C	oursey E	lvd, Bld	g 7 Suite	: A	Analysis Category:	ENVIR	ONMENT	AL		
Laboration		•	•						, ,					
Pe	LabID		ClientID	SampleDate			BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
18-06116-05   TRG   33-01-62-180620   0620/18 00.00   6262018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   2.21E-01   2.72E-00   2.94E-00   1.58E-00   p.City   18-06116-05   TRG   33-01-62-180620   0620/18 00.00   62620/18 7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   1.75E-00   2.7E-01   2.50E-01   3.03E-01   p.City   18-06116-05   TRG   33-01-62-180620   0620/18 00.00   62620/18 7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   1.27E-00   1.96E-01   2.00E-01   2.00E-0		100		·				•						·
18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-2/12   EPA 901.1 Modified   4.00E+00   6.21E+00   6.21E+00   1.02E+01   DCUg		-												pCi/g
18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   1.27E-00   2.60E-01   2.00E-01   2.00E-01   D/Ug   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radum-26   EPA 901.1 Modified   1.27E-00   1.90E-01   2.00E-01   2.00E-01   D/Ug   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   1.27E-00   1.90E-01   2.07E-01   2.20E-01   D/Ug   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   1.66E+00   3.03E-01   3.14E-01   2.85E-01   D/Ug   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thailium-208   EPA 901.1 Modified   1.30E+00   3.03E-01   3.14E-01   2.85E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Actinium-228   EPA 901.1 Modified   1.30E+00   3.03E-01   3.10E-01   4.33E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   EPA 901.1 Modified   1.10E+00   2.02E-01   2.10E-01   2.33E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   EPA 901.1 Modified   1.10E+00   2.02E-01   2.10E-01   2.33E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   EPA 901.1 Modified   2.01E+01   2.52E+00   2.72E-01   2.28E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   EPA 901.1 Modified   2.01E+01   3.48E-01   3.64E-01   2.00E-01   D/Ug   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Ead-212   EPA 901.1 Modified   2.01E+00   3.49E-01   3.64E-01   2.20E-01   2.2		-						-				_		
18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-214   EPA 901.1 Modified   1.24E+00   1.90E-01   2.00E-01   2.40E-01   P.DUE   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   1.27E+00   1.96E-01   1.96E-01   2.07E-01   2.30E-01   P.DUE   18-06116-05   TRG   33-01-62-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thailium-208   EPA 901.1 Modified   0.66E+00   3.01E+00   3.01E+00   3.01E+00   0.00E-01   0.00E-		-			_							-		
18-06116-05 TRG 33-01-62-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 2.06E+00 1.81E+00 1.96E-01 2.07E-01 2.30E-01 pC/lg 18-06116-05 TRG 33-01-62-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.06E+00 3.03E-01 3.14E-01 2.85E-01 pC/lg 18-06116-05 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinium-228 EPA 901.1 Modified 1.30E+00 3.03E-01 3.14E-01 2.85E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Polassium-40 EPA 901.1 Modified 1.00E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Polassium-40 EPA 901.1 Modified 2.01E+01 2.52E+00 2.72E+00 1.23E-00 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Polassium-40 EPA 901.1 Modified 2.01E+01 2.52E+00 2.72E+00 1.23E-00 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protactinium-234m EPA 901.1 Modified 2.01E+01 2.52E+00 2.72E+00 1.23E-00 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E+01 2.52E+00 2.25E-01 2.25E-01 2.01E-01 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E+00 3.49E-01 3.64E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-07 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 3.19E+00 1.52E+00 2.16E-01 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 EPA 901.1 Modified 1.26E+00 2.67E-01	18-06116-05	-	33-01-62-180620	06/20/18 00:00	6/26/2018		18-06116	Lead-212	EPA 901.1 Modified	1.57E+00	2.47E-01	2.60E-01		pCi/g
18-06116-05 TRG 33-01-62-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.66E+00 3.03E-01 3.14E-01 2.85E-01 pC/lg 18-06116-05 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinium-228 EPA 901.1 Modified 1.30E+00 3.03E-01 3.14E-01 2.85E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 2.01E-01 2.5EE-00 2.72E+00 1.23E-00 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E-01 3.48E-01 2.46E-01 2.34E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 1.10E+00 2.23E-01 2.3E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 1.10E+00 3.49E-01 3.46E-01 2.24E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.17E-00 2.23E-01 2.3E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.10E+00 2.02E-01 2.3E-01 2.24E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-248 EPA 901.1 Modified 1.10E+00 2.23E-01 2.3E-01 2.24E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-248 EPA 901.1 Modified 1.10E+00 2.26E-01 2.5E-01 2.25E-01 3.6E-01 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-248 EPA 901.1 Modified 1.09E+00 1.5EE+00 2.6EE-01 3.6EE-01 3.6EE-01 2.5EE-01 3.6EE-01 2.5EE-01 2.5EE-01 3.6EE-01 3.5EE-01 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 1.26E-00 2.6EE-01 2.5EE-01 3.6EE-01 3.5EE-01 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116		-	33-01-62-180620	06/20/18 00:00	-			Lead-214	EPA 901.1 Modified					pCi/g
18-06116-05   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Tallium-208   EPA 901.1 Modified   1.30E+00   3.03E-01   3.14E-01   2.85E-01   PC/07	18-06116-05	TRG	33-01-62-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.27E+00	1.96E-01	2.07E-01	2.30E-01	pCi/g
18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Bismuth-214   EPA 901.1 Modified   1.30E+00   2.02E-01   2.10E-01   2.33E-10   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Bismuth-214   EPA 901.1 Modified   1.01E+00   2.02E-01   2.10E-01   2.33E-10   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protectinium-234m   EPA 901.1 Modified   2.01E+01   2.52E+00   2.72E+00   2.33E-10   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protectinium-234m   EPA 901.1 Modified   2.01E+01   3.49E-01   3.64E-01   2.80E-01   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   2.01E+00   3.49E-01   3.64E-01   2.80E-01   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   1.17E+00   2.23E-01   2.31E-01   2.24E-01   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   1.10E+00   2.02E-01   2.10E-01   2.34E-01   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   1.09E+00   2.15E-01   2.22E-01   3.21E-01   PC/lg   18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   1.09E+00   2.15E-01   2.22E-01   3.21E-01   PC/lg   18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-228   EPA 901.1 Modified   1.26E+00   2.67E-01   2.75E-01   3.68E-01   PC/lg   18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Pc/lg   18-06116   Pc/lg   18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Pc/lg   18-06116   Pc/lg   18-06116   Pc/lg   18-06116   Pc/lg	18-06116-05	TRG	33-01-62-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	2.06E+00	1.81E+00	1.81E+00	3.01E+00	pCi/g
18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   1.10E+00   2.02E-01   2.10E-01   2.33E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   2.01E+01   2.52E+00   2.72E+00   1.23E+00   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   4.109E+00   6.64E+00   6.64E+00   9.97E+00   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   4.10F+00   2.23E-01   2.34E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-214   EPA 901.1 Modified   4.10F+00   2.23E-01   2.34E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   4.10F+00   2.02E-01   2.31E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   4.10F+00   2.02E-01   2.10E-01   2.33E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   4.10F+00   2.02E-01   4.51E-00   2.10E-01   2.25E-01   3.21E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-228   EPA 901.1 Modified   4.26E+00   2.67E-01   2.5E-01   2.5E-01   4.51E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protactinium-228   EPA 901.1 Modified   4.26E+00   2.67E-01   2.5E-01   4.51E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protactinium-234   EPA 901.1 Modified   4.10E+00   3.0E+00   3.	18-06116-05	TRG	33-01-62-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.66E+00	3.03E-01	3.14E-01	2.85E-01	pCi/g
18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   1.10E+00   2.02E-01   2.10E-01   2.33E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   2.01E+01   2.52E+00   2.72E+00   1.23E+00   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Potassium-40   EPA 901.1 Modified   4.109E+00   6.64E+00   6.64E+00   9.97E+00   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-212   EPA 901.1 Modified   4.10F+00   2.23E-01   2.34E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-214   EPA 901.1 Modified   4.10F+00   2.23E-01   2.34E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   4.10F+00   2.02E-01   2.31E-01   2.24E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Radium-226   EPA 901.1 Modified   4.10F+00   2.02E-01   2.10E-01   2.33E-01   PC/lig 18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-234   EPA 901.1 Modified   4.10F+00   2.02E-01   4.51E-00   2.10E-01   2.25E-01   3.21E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Thorium-228   EPA 901.1 Modified   4.26E+00   2.67E-01   2.5E-01   2.5E-01   4.51E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protactinium-228   EPA 901.1 Modified   4.26E+00   2.67E-01   2.5E-01   4.51E-01   PC/lig 18-06116-07   TRG   33-03-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Protactinium-234   EPA 901.1 Modified   4.10E+00   3.0E+00   3.														
18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 2.01E+01 2.52E+00 2.72E+00 1.23E+00 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E+00 3.49E-01 3.64E-01 2.80E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.17E+00 2.23E-01 2.31E-01 2.24E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.17E+00 2.23E-01 2.31E-01 2.24E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.09E+00 2.15E-01 2.22E-01 3.21E-01 pC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 1.09E+00 2.15E-01 2.22E-01 3.21E-01 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinium-228 EPA 901.1 Modified 1.09E+00 2.15E-01 2.22E-01 3.21E-01 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.11E+00 3.07E+00 1.52E+00 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.11E+00 7.71E+00 1.52E+00 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.11E+00 7.71E+00 1.52E+00 pC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.11E+00 3.13E-01 3.26E-01 3	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.30E+00	3.03E-01	3.10E-01	4.33E-01	pCi/g
18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protactinium-234m EPA 901.1 Modified -1.09E+00 6.64E+00 9.97E+00 PC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E+00 3.49E-01 3.64E-01 2.80E-01 PC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 PC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 3.19E+00 1.51E+00 1.52E+00 2.16E+00 PC/lg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 3.19E+00 1.51E+00 1.52E+00 2.16E+00 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinium-228 EPA 901.1 Modified 1.09E+00 2.15E-01 2.22E-01 3.21E-01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 1.09E+00 2.51E-01 2.75E-01 3.68E-01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 7.77E+00 3.68E-01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 7.77E+00 1.34E+01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 7.77E+00 1.34E+01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 7.77E+00 1.34E+01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 7.77E+00 1.34E+01 PC/lg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 5.11E+00 3.05E+00 3.05E+00 3.05E+00 5.05E+00 5.05E+00	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.10E+00	2.02E-01	2.10E-01	2.33E-01	pCi/g
18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 2.01E+00 3.49E-01 3.64E-01 2.80E-01 PC/Vg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.17E+00 2.23E-01 2.31E-01 2.24E-01 PC/Vg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.10E+00 2.02E-01 2.10E-01 2.33E-01 PC/Vg 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 3.19E+00 1.51E+00 1.52E+00 2.16E+00 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinum-228 EPA 901.1 Modified 1.09E+00 2.16E-01 2.22E-01 3.21E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 1.26E+00 2.67E-01 2.75E-01 3.68E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.16E+01 2.86E+00 3.07E+00 1.52E+00 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.16E+01 2.86E+00 3.07E+00 1.52E+00 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protassium-40 EPA 901.1 Modified 5.16E+01 7.77E+00 7.77E+00 1.34E+01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-224 EPA 901.1 Modified 1.36E+00 2.04E-01 2.56E-01 2.89E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.36E+00 2.04E-01 2.56E-01 2.89E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 1.36E+00 2.04E-01 2.56E-01 2.89E-01 PC/Vg 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 8.	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.01E+01	2.52E+00	2.72E+00	1.23E+00	pCi/g
18-06116-06   TRG   33-02-61-180620   06/20/18 00:00   6/26/2018   7/19/2018   18-06116   Lead-214   EPA 901.1 Modified   1.17E+00   2.23E-01   2.31E-01   2.24E-01   PC/I/C	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	-1.09E+00	6.64E+00	6.64E+00	9.97E+00	pCi/g
18-06116-06         TRG         33-02-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         1.10E+00         2.02E-01         2.10E-01         2.33E-01         pCity           18-06116-06         TRG         33-02-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thorium-234         EPA 901.1 Modified         1.09E+00         2.15E-01         2.22E-01         3.21E-01         pCity           18-06116-07         TRG         33-02-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Actinium-208         EPA 901.1 Modified         1.09E+00         2.15E-01         2.22E-01         3.21E-01         pCity         18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Actinium-228         EPA 901.1 Modified         1.26E+00         2.67E-01         2.75E-01         3.68E-01         pCity         18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Bismuth-214         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCity         18-06116-07         TRG <td< td=""><td>18-06116-06</td><td>TRG</td><td>33-02-61-180620</td><td>06/20/18 00:00</td><td>6/26/2018</td><td>7/19/2018</td><td>18-06116</td><td>Lead-212</td><td>EPA 901.1 Modified</td><td>2.01E+00</td><td>3.49E-01</td><td>3.64E-01</td><td>2.80E-01</td><td>pCi/g</td></td<>	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	2.01E+00	3.49E-01	3.64E-01	2.80E-01	pCi/g
18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 3.19E+00 1.51E+00 1.52E+00 2.16E+00 PC//s 18-06116-06 TRG 33-02-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thallium-208 EPA 901.1 Modified 1.09E+00 2.15E-01 2.22E-01 3.21E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 2.16E+00 3.07E+00 1.52E+00 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Potassium-40 EPA 901.1 Modified 2.16E+01 2.86E+00 3.07E+00 1.52E+00 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protactinium-234m EPA 901.1 Modified 5.11E+00 7.71E+00 7.72E+00 1.34E+01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 1.36E+00 3.13E-01 3.26E-01 3.35E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-212 EPA 901.1 Modified 1.36E+00 2.04E-01 2.16E-01 2.89E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.36E+00 2.04E-01 2.16E-01 2.89E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Radium-226 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 9.82E-01 2.46E-01 2.51E-01 4.51E-01 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 8.51E+00 3.52E+00 8.53E+00 8.53E+00 PC//s 18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 8.51E+00 3.52	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.17E+00	2.23E-01	2.31E-01	2.24E-01	pCi/g
18-06116-06         TRG         33-02-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thallium-208         EPA 901.1 Modified         1.09E+00         2.15E-01         2.22E-01         3.21E-01         PC/V/C           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Actinium-228         EPA 901.1 Modified         1.26E+00         2.67E-01         2.75E-01         3.68E-01         PC/V/C           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Bismuth-214         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pC/V/C           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Potassium-40         EPA 901.1 Modified         2.16E-01         2.86E+00         3.07E+00         1.52E+00         pC/V/C           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Protactinium-234m         EPA 901.1 Modified         5.11E+00         7.71E+00         7.72E+00         1.34E+01         pC/V/C	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.10E+00	2.02E-01	2.10E-01	2.33E-01	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Actinium-228         EPA 901.1 Modified         1.26E+00         2.67E-01         2.75E-01         3.68E-01         PCI/G           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Bismuth-214         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/G           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Potassium-40         EPA 901.1 Modified         2.16E+01         2.86E+00         3.07E+00         1.52E+00         pCi/G         18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Protactinium-234m         EPA 901.1 Modified         5.11E+00         7.71E+00         7.72E+00         1.34E+01         pCi/G           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-212         EPA 901.1 Modified         1.78E+00         3.13E-01         3.26E-01         3.35E-01         pCi/G           18-0611	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	3.19E+00	1.51E+00	1.52E+00	2.16E+00	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Bismuth-214         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         PC//s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Potassium-40         EPA 901.1 Modified         2.16E+01         2.86E+00         3.07E+00         1.52E+00         pC//s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Protactinium-234m         EPA 901.1 Modified         5.11E+00         7.71E+00         7.72E+00         1.34E+01         pC//s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-212         EPA 901.1 Modified         1.78E+00         3.13E-01         3.26E-01         3.35E-01         pC//s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-214         EPA 901.1 Modified         1.36E+00         2.04E-01         2.16E-01         2.89E-01         pC//s	18-06116-06	TRG	33-02-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.09E+00	2.15E-01	2.22E-01	3.21E-01	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Potassium-40         EPA 901.1 Modified         2.16E+01         2.86E+00         3.07E+00         1.52E+00         PC//2018           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Protactinium-234m         EPA 901.1 Modified         5.11E+00         7.71E+00         7.72E+00         1.34E+01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-212         EPA 901.1 Modified         1.78E+00         3.13E-01         3.26E-01         3.35E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-214         EPA 901.1 Modified         1.36E+00         2.04E-01         2.16E-01         2.89E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/g	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.26E+00	2.67E-01	2.75E-01	3.68E-01	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Protactinium-234m         EPA 901.1 Modified         5.11E+00         7.71E+00         7.72E+00         1.34E+01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-212         EPA 901.1 Modified         1.78E+00         3.13E-01         3.26E-01         3.35E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-214         EPA 901.1 Modified         1.36E+00         2.04E-01         2.16E-01         2.89E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thorium-234         EPA 901.1 Modified         8.51E+00         3.52E+00         8.53E+00         PCi/g	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	9.82E-01	2.46E-01	2.51E-01	4.51E-01	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-212         EPA 901.1 Modified         1.78E+00         3.13E-01         3.26E-01         3.35E-01         pCi/s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-214         EPA 901.1 Modified         1.36E+00         2.04E-01         2.16E-01         2.89E-01         pCi/s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/s           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thorium-234         EPA 901.1 Modified         8.51E+00         3.52E+00         8.53E+00         9.00/20/20/20/20/20/20/20/20/20/20/20/20/2	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.16E+01	2.86E+00	3.07E+00	1.52E+00	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Lead-214         EPA 901.1 Modified         1.36E+00         2.04E-01         2.16E-01         2.89E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thorium-234         EPA 901.1 Modified         8.51E+00         3.52E+00         3.54E+00         8.53E+00         pCi/g	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	5.11E+00	7.71E+00	7.72E+00	1.34E+01	pCi/g
18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Radium-226         EPA 901.1 Modified         9.82E-01         2.46E-01         2.51E-01         4.51E-01         pCi/g           18-06116-07         TRG         33-03-61-180620         06/20/18 00:00         6/26/2018         7/19/2018         18-06116         Thorium-234         EPA 901.1 Modified         8.51E+00         3.52E+00         3.54E+00         8.53E+00         PCi/g	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.78E+00	3.13E-01	3.26E-01	3.35E-01	pCi/g
18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thorium-234 EPA 901.1 Modified 8.51E+00 3.52E+00 8.53E+00 PCi/c	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.36E+00	2.04E-01	2.16E-01	2.89E-01	pCi/g
	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	9.82E-01	2.46E-01	2.51E-01	4.51E-01	pCi/g
18-06116-07 TRG 33-03-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Thallium-208 EPA 901.1 Modified 1.19E+00 2.68E-01 2.75E-01 2.60E-01 pCi/s	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	8.51E+00	3.52E+00	3.54E+00	8.53E+00	pCi/g
	18-06116-07	TRG	33-03-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.19E+00	2.68E-01	2.75E-01	2.60E-01	pCi/g
18-06116-08 TRG 33-04-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Actinium-228 EPA 901.1 Modified 1.35E+00 2.84E-01 2.93E-01 4.40E-01 pCi/g	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.35E+00	2.84E-01	2.93E-01	4.40E-01	pCi/g
18-06116-08 TRG 33-04-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Bismuth-214 EPA 901.1 Modified 1.20E+00 2.01E-01 2.10E-01 1.88E-01 pCi/c	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.20E+00	2.01E-01	2.10E-01	1.88E-01	pCi/g
	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.13E+01	2.58E+00	2.80E+00	1.35E+00	pCi/g
18-06116-08 TRG 33-04-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Protactinium-234m EPA 901.1 Modified 4.00E+00 5.45E+00 9.12E+00 pCi/c	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	4.00E+00	5.45E+00	5.45E+00	9.12E+00	pCi/g
	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.36E+00	2.21E-01	2.32E-01	3.20E-01	pCi/g
18-06116-08 TRG 33-04-61-180620 06/20/18 00:00 6/26/2018 7/19/2018 18-06116 Lead-214 EPA 901.1 Modified 1.23E+00 1.93E-01 2.03E-01 2.87E-01 pCi/c	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.23E+00	1.93E-01	2.03E-01	2.87E-01	pCi/g
	18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.20E+00	2.01E-01	2.10E-01	1.88E-01	pCi/g

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					Report To:			Work Order Details:					
Fhor	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-0	6116-Re	evised		
		~	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Fina	I Rep	ort of Analysis	13702 C	oursey E	Blvd, Bld	g 7 Suite	· A	Analysis Category:	ENVIR	ONMENT	AL		
	•	•		ouge, LA				Sample Matrix:	SO				
LabID	SampleTy	ClientID	SampleDate	ReceiptDat	AnalysisDa	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
	pe		·	е	te		•						
18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	1.70E+00	1.92E+00	1.93E+00	3.22E+00	pCi/g
18-06116-08	TRG	33-04-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.26E+00	2.02E-01	2.12E-01	2.71E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.58E+00	3.28E-01	3.38E-01	4.02E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.33E+00	2.12E-01	2.23E-01	2.53E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.13E+01	2.59E+00	2.81E+00	1.12E+00	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	2.08E+00	4.86E+00	4.87E+00	1.01E+01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.57E+00	2.61E-01	2.73E-01	2.79E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.34E+00	2.19E-01	2.30E-01	2.54E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.33E+00	2.12E-01	2.23E-01	2.53E-01	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	2.51E+00	1.98E+00	1.98E+00	3.28E+00	pCi/g
18-06116-09	TRG	33-05-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.14E+00	2.18E-01	2.25E-01	3.29E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.93E+00	3.92E-01	4.04E-01	6.44E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.18E+00	2.40E-01	2.47E-01	3.71E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.07E+01	2.75E+00	2.95E+00	1.14E+00	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	4.80E+00	8.06E+00	8.06E+00	1.41E+01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	2.01E+00	3.74E-01	3.88E-01	4.23E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.53E+00	2.45E-01	2.57E-01	4.08E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.18E+00	2.40E-01	2.47E-01	3.71E-01	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	-6.17E-01	4.70E-01	4.71E-01	3.04E+00	pCi/g
18-06116-10	TRG	33-06-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.65E+00	3.47E-01	3.57E-01	6.16E-02	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.63E+00	3.86E-01	3.95E-01	8.24E-01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.39E+00	2.84E-01	2.93E-01	1.18E-01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.10E+01	3.03E+00	3.22E+00	1.91E+00	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	5.88E+00	9.87E+00	9.87E+00	1.72E+01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.36E+00	2.62E-01	2.71E-01	3.42E-01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.12E+00	2.59E-01	2.65E-01	3.62E-01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.39E+00	2.84E-01	2.93E-01	1.18E-01	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	2.17E+00	1.98E+00	1.99E+00	3.31E+00	pCi/g
18-06116-11	TRG	33-07-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.28E+00	2.63E-01	2.71E-01	6.74E-02	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.49E+00	2.81E-01	2.91E-01	4.54E-01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.34E+00	1.94E-01	2.06E-01	2.00E-01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.24E+01	2.67E+00	2.91E+00	1.23E+00	pCi/g

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				Report To:					Work Order Details:				
Fhei	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-0	6116-Re	evised		
		_	Weston	Solution	s, Inc.			Purchase Order:	00951	31			
Fina	ıl Rep	ort of Analysis	13702 C	oursey E	Blvd, Bld	g 7 Suite	: A	Analysis Category:	ENVIR	CONMENT	AL		
	•	•	Baton Rouge, LA 70817-1370				Sample Matrix:	SO					
LabID	SampleTy pe	ClientID	SampleDate		AnalysisDa te	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnits
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	-1.36E-01	6.75E+00	6.75E+00	1.03E+01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.32E+00	2.22E-01	2.32E-01	2.56E-01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.06E+00	1.80E-01	1.88E-01	2.17E-01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.34E+00	1.94E-01	2.06E-01	2.00E-01	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	1.98E+00	1.51E+00	1.51E+00	2.06E+00	pCi/g
18-06116-12	TRG	33-08-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.14E+00	1.96E-01	2.05E-01	1.83E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.50E+00	3.50E-01	3.58E-01	5.46E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.01E+00	2.03E-01	2.10E-01	3.23E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	1.80E+01	2.50E+00	2.67E+00	1.63E+00	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	-2.85E+00	7.26E+00	7.26E+00	1.14E+01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.65E+00	3.15E-01	3.26E-01	3.53E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	2.41E+00	3.80E-01	3.99E-01	6.16E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.01E+00	2.03E-01	2.10E-01	3.23E-01	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	6.90E+00	2.47E+00	2.49E+00	8.15E+00	pCi/g
18-06116-13	TRG	33-09-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.36E+00	2.68E-01	2.77E-01	2.40E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Actinium-228	EPA 901.1 Modified	1.05E+00	4.09E-01	4.13E-01	7.32E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Bismuth-214	EPA 901.1 Modified	1.22E+00	2.27E-01	2.36E-01	1.05E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Potassium-40	EPA 901.1 Modified	2.09E+01	2.80E+00	2.99E+00	1.02E+00	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Protactinium-234m	EPA 901.1 Modified	6.60E+00	9.12E+00	9.13E+00	1.60E+01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-212	EPA 901.1 Modified	1.30E+00	2.49E-01	2.58E-01	3.24E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Lead-214	EPA 901.1 Modified	1.12E+00	2.33E-01	2.40E-01	2.95E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Radium-226	EPA 901.1 Modified	1.22E+00	2.27E-01	2.36E-01	1.05E-01	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thorium-234	EPA 901.1 Modified	1.33E+00	1.34E+00	1.34E+00	2.05E+00	pCi/g
18-06116-14	TRG	33-10-61-180620	06/20/18 00:00	6/26/2018	7/19/2018	18-06116	Thallium-208	EPA 901.1 Modified	1.24E+00	2.88E-01	2.94E-01	2.75E-01	pCi/g

**MEMO** 

DATE: June 27, 2019

TO: Keith Delhomme, Robert Sherman

FROM: Rick Haaker RF Hawher

SUBJECT: Review of Gamma Spectroscopy Data Package, 18-06116

The file evaluated was 1806116-revised.EDD.xls. Don't know how it was revised or by whom.

This package consisted of 11 soil samples (1 of which was a replicate count that was analyzed twice for a total of 12 results), plus method blanks, lab control standards/spikes. All concentration units are in units of pCi/g, unless otherwise noted. The results are considered acceptable for use, except where noted otherwise. The following samples were analyzed by gamma spectroscopy.

Sam	SampleID_Table										
ClientID	LabID	Sample Type									
33-01-61-180620	18-06116-03	DUP									
33-01-61-180620	18-06116-04	DO									
33-01-62-180620	18-06116-05	TRG									
33-02-61-180620	18-06116-06	TRG									
33-03-61-180620	18-06116-07	TRG									
33-04-61-180620	18-06116-08	TRG									
33-05-61-180620	18-06116-09	TRG									
33-06-61-180620	18-06116-10	TRG									
33-07-61-180620	18-06116-11	TRG									
33-08-61-180620	18-06116-12	TRG									
33-09-61-180620	18-06116-13	TRG									
33-10-61-180620	18-06116-14	TRG									

The data was delivered in the usual Microsoft excel data format.

No isotopes were detected in the method blank samples at levels that exceeded the minimum detectable activity. Detected activity in the blanks is not a good thing.

The agreement between duplicate sample results was acceptable, except that thallium-208 is more uncertain than usual. The duplicate had about 1.3 pCi/g radium-226, which is good. All radium-226 values were about 1 pCi/g.

Thorium-234 results were considerably more precise than protactinium-234m results. The protactinium-234m results should not by themselves be considered reliable. Th-234 was reported as present at levels that exceed the minimum detectable activity in samples as follows. Results are in the units of pCi/g.

Detected Th234				
ClientID	Analyte	Results	MDAC	
33-02-61-180620	Thorium-234	3.19	2.16	

Ignoring protactinium-234m, all other uranium decay chain analytes were detected in all samples except as follows:

NonDetects				
ClientID	Analyte	Result	MDAC	ReportUnits
33-01-61-180620	Thorium-234	0.59	2.2578	pCi/g
33-01-62-180620	Thorium-234	2.06	3.0073	pCi/g
33-03-61-180620	Thorium-234	8.51	8.5348	pCi/g
33-04-61-180620	Thorium-234	1.7	3.2213	pCi/g
33-05-61-180620	Thorium-234	2.51	3.2801	pCi/g
33-06-61-180620	Thorium-234	-0.62	3.0442	pCi/g
33-07-61-180620	Thorium-234	2.17	3.3067	pCi/g
33-08-61-180620	Thorium-234	1.98	2.062	pCi/g
33-09-61-180620	Thorium-234	6.9	8.1477	pCi/g
33-10-61-180620	Thorium-234	1.33	2.0513	pCi/g

This Eberline data package reports radium-226 as equal to bismuth-214, the radium-226 being assigned from the bismuth-214 values.

The degree of agreement between thorium-234 and radium-226 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that the thorium-234 results might be seriously biased by systematic error. The test statistic is the number of standard deviations by which the thorium-234 result exceeds the radium-226 result. If the test statistic is substantially less than zero, it implies that the reported radium-226 concentration is greater than the thorium-234 concentration. Gamma spectroscopy cannot detect thorium-230, so agreement between thorium-234 and radium-226 doesn't provide any information about equilibrium between thorium-230 and radium-226.

'Equilibrium' Th234 → Ra226			
ClientID	Test Statistic	Disequilibrium Evidence	
33-01-61-180620	-0.88	Weak or none	
33-01-61-180620	-0.69	Weak or none	
33-01-62-180620	0.87	Weak or none	
33-02-61-180620	2.73	Strong	
33-03-61-180620	4.24	Strong	
33-04-61-180620	0.52	Weak or none	
33-05-61-180620	1.18	Weak or none	
33-06-61-180620	-6.76	Strong	
33-07-61-180620	0.78	Weak or none	

'Equilibrium' Th234 → Ra226			
ClientID	Test Statistic	Disequilibrium Evidence	
33-08-61-180620	0.84	Weak or none	
33-09-61-180620	4.71	Strong	
33-10-61-180620	0.15	Weak or none	

The degree of agreement between radium-226 and lead-210 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that there is no proficiency testing of radiochemistry laboratories for isotopes having gamma energies similar to those for lead-210. The test statistic is the number of standard deviations by which the radium-226 result exceeds the lead-210 result. If the test statistic is substantially less than zero, it implies that the reported lead-210 concentration is greater than the radium-226 concentration. Agreement between radium-226 and lead-210 doesn't provide *any* information about equilibrium between thorium-230 and radium-226.

No Lead-210 results were reported for this data package.

Twenty-three days elapsed from the date of receipt by Eberline to the date of analysis in their laboratory, which is good. At least twenty-one days normally occurs between sealing and counting.

My impression is that the laboratory analyses are acceptable for use, except that thallium-208 was more uncertain than usual.

The maximum and estimated 99%UCLs (assuming normal statistics) for nuisance radionuclides in pCi/g, based on all prior datasets reviewed to this point are:

Analyte	Maximum	UCL99%
Actinium-228	2.44	2.26
Lead-212	8.45	4.1
Potassium-40	35.46	33.05
Thallium-208	2.45	2.04

For this dataset (data package), the following matrix of linear correlation coefficients was obtained for samples having a radium-226 concentration below 10pCi/g. Correlation coefficients can have a range between 1 and -1, and are a measure of tendency of pairs of *reported* isotopic concentrations to go up and down together in a linear fashion. These correlation coefficients are based on observations in the concentration range of interest to project engineers.

### 18-06116

	Ac_228	Bi _214	Pb_212	Pb_214	K_40	Pa_234m	Ra_226	TI _208	Th_234
Ac_228	1.00	0. 28	0. 28	0. 21	-0. 13	0. 01	0. 28	0. 24	-0. 36
Bi _214	0. 28	1.00	-0. 58	-0. 61	0. 55	0. 22	1.00	0.05	-0. 72
Pb_212	0. 28	-0. 58	1.00	0. 31	-0. 32	-0. 21	-0. 58	0. 18	0. 19
Pb_214	0. 21	-0. 61	0. 31	1.00	-0. 79	-0.40	-0. 61	0. 17	0. 51
K_40	-0. 13	0. 55	-0. 32	-0. 79	1.00	0. 21	0. 55	0. 19	-0. 38
Pa_234m	0. 01	0. 22	-0. 21	-0.40	0. 21	1.00	0. 22	-0. 18	-0. 19
Ra_226	0. 28	1.00	-0. 58	-0. 61	0. 55	0. 22	1.00	0. 05	-0. 72
TI _208	0. 24	0.05	0. 18	0. 17	0. 19	-0. 18	0.05	1.00	-0. 35
Th_234	-0. 36	-0. 72	0. 19	0. 51	-0. 38	-0. 19	-0. 72	-0. 35	1.00

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			Report To:						Work Order Details:						
Fber	rline	<b>Analytical</b>	Jeff Wr	ight				SDG:	18-1	0018 -	Revise	d			
		_	Westor	n Solutio	ns, Inc.			Purchase Order:	00951	31					
Fina	l Rep	ort of Analysis	13702 (	Coursey	Blvd, Blo	dg 7 Sui	te A	Analysis Category:	ENVI	RONMEN	TAL				
	•	-	Baton I	Rouge, L	A 70817	-1370		Sample Matrix:	SO						
LabID	SampleTy pe	ClientID	SampleDate	ReceiptDat e	AnalysisDa te	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnit s		
18-10018-01	LCS	KNOWN	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Cobalt-60	EPA 901.1 Modified	6.21E+01	2.48E+00			pCi/g		
18-10018-01	LCS	KNOWN	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Cesium-137	EPA 901.1 Modified	3.94E+01	1.58E+00			pCi/g		
18-10018-01	LCS	SPIKE	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Cobalt-60	EPA 901.1 Modified	7.11E+01	4.74E+00	5.98E+00	7.37E-01	pCi/g		
18-10018-01	LCS	SPIKE	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Cesium-137	EPA 901.1 Modified	4.38E+01	3.94E+00	4.54E+00	5.36E-01	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	-2.95E-02	1.02E-01	1.02E-01	1.60E-01	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	3.50E-02	3.86E-02	3.86E-02	6.12E-02	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	2.00E-01	2.15E-01	2.15E-01	4.98E-01	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	2.17E+00	1.85E+00	1.85E+00	2.66E+00	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	2.05E-01	1.29E-01	1.29E-01	2.23E-01	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	1.62E-02	2.24E-02	2.24E-02	3.79E-02	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	7.74E-03	3.53E-02	3.53E-02	5.70E-02	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	3.50E-02	3.86E-02	3.86E-02	6.12E-02	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	3.66E-02	1.79E-01	1.79E-01	2.74E-01	pCi/g		
18-10018-02	MBL	BLANK	10/03/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	3.21E-02	5.38E-02	5.39E-02	9.25E-02	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	2.07E+00	2.83E-01	3.02E-01	4.13E-01	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	3.77E+00	4.27E-01	4.69E-01	2.57E-01	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	2.22E+01	2.28E+00	2.55E+00	1.25E+00	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	4.26E+00	5.98E+00	5.99E+00	9.78E+00	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	3.19E+00	1.85E+00	1.86E+00	3.02E+00	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	2.24E+00	2.10E-01	2.39E-01	2.56E-01	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	3.98E+00	1.06E+00	1.08E+00	2.49E-01	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	3.77E+00	4.27E-01	4.69E-01	2.57E-01	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	8.69E+00	2.21E+00	2.25E+00	6.77E+00	pCi/g		
18-10018-03	DUP	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	1.45E+00	2.22E-01	2.34E-01	1.09E-01	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	2.15E+00	3.13E-01	3.32E-01	4.67E-01	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	3.84E+00	4.40E-01	4.82E-01	2.85E-01	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	2.29E+01	2.31E+00	2.59E+00	1.13E+00	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	6.34E+00	5.98E+00	5.99E+00	9.87E+00	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	3.18E+00	1.66E+00	1.67E+00	2.69E+00	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	2.44E+00	2.22E-01	2.55E-01	2.39E-01	pCi/g		
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	3.90E+00	1.00E+00	1.02E+00	2.79E-01	pCi/g		

CU=Counting Uncertainty; CSU=Combined Standard Uncertainty (1-sigma); MDA=Minimal Detected Activity; LCS=Laboratory Control Sample; MBL=Blank; DUP=Duplicate; TRG=Normal Sample; DO=Duplicate Original

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					Report To:				Wo	rk Order Detai	ils:		
Fhai	rline	<b>Analytical</b>	Jeff Wr	ight				SDG:	18-1	0018 -	Revise	d	
		•	Westor	Solutio	ns, Inc.			Purchase Order:	00951	31			
Fina	I Rep	ort of Analysis	13702 (	Coursey	Blvd, Blo	dq 7 Sui	te A	Analysis Category:	ENVI	RONMEN	TAL		
	•	•		Rouge, L				Sample Matrix:	SO				
Labib	SampleTy	OlleralD			AnalysisDa		Australia	,		011	0011	MDA	ReportUnit
LabID	pe	ClientID	SampleDate	e	te	BatchID	Analyte	Method	Result	CU	CSU	MDA	s
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	3.84E+00	4.40E-01	4.82E-01	2.85E-01	pCi/g
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	3.27E+00	1.75E+00	1.75E+00	2.71E+00	pCi/g
18-10018-04	DO	33-23-2-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	1.63E+00	2.38E-01	2.52E-01	1.13E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	8.99E-01	2.72E-01	2.76E-01	6.36E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	5.27E+01	3.28E+00	4.25E+00	3.68E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	2.08E+01	2.49E+00	2.71E+00	2.38E+00	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	5.42E+01	1.50E+01	1.53E+01	2.20E+01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	3.07E+01	3.44E+00	3.78E+00	4.29E+00	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	7.36E-01	1.48E-01	1.52E-01	4.38E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	5.20E+01	6.23E+00	6.78E+00	4.52E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	5.27E+01	3.28E+00	4.25E+00	3.68E-01	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	4.89E+01	4.75E+00	5.37E+00	5.46E+00	pCi/g
18-10018-05	TRG	33-26-31-180807	08/07/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	9.47E-01	1.78E-01	1.85E-01	6.36E-02	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	2.32E+00	2.39E-01	2.67E-01	2.58E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	2.52E+00	2.52E-01	2.83E-01	1.51E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	1.70E+01	1.79E+00	1.99E+00	7.15E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	3.25E+00	3.81E+00	3.82E+00	6.11E+00	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	1.06E+00	9.02E-01	9.04E-01	1.50E+00	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	2.74E+00	3.30E-01	3.59E-01	1.47E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	2.48E+00	3.15E-01	3.40E-01	1.57E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	2.52E+00	2.52E-01	2.83E-01	1.51E-01	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	3.64E+00	1.28E+00	1.30E+00	2.07E+00	pCi/g
18-10018-06	TRG	33-28-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	2.22E+00	2.97E-01	3.19E-01	1.83E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Actinium-228	EPA 901.1 Modified	2.44E+00	2.83E-01	3.10E-01	6.33E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Bismuth-214	EPA 901.1 Modified	2.47E+00	2.48E-01	2.79E-01	2.44E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Potassium-40	EPA 901.1 Modified	1.90E+01	2.61E+00	2.79E+00	1.59E+00	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Protactinium-234m	EPA 901.1 Modified	2.61E+00	6.76E+00	6.77E+00	1.10E+01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-210	EPA 901.1 Modified	7.93E-01	5.71E-01	5.73E-01	9.48E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-212	EPA 901.1 Modified	2.79E+00	2.81E-01	3.15E-01	2.60E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Lead-214	EPA 901.1 Modified	2.63E+00	2.29E-01	2.66E-01	3.11E-01	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Radium-226	EPA 901.1 Modified	2.47E+00	2.48E-01	2.79E-01	2.44E-01	pCi/g

CU=Counting Uncertainty; CSU=Combined Standard Uncertainty (1-sigma); MDA=Minimal Detected Activity; LCS=Laboratory Control Sample; MBL=Blank; DUP=Duplicate; TRG=Normal Sample; DO=Duplicate Original

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			Report To:					Work Order Details:					
Fhei	rline	<b>Analytical</b>	Jeff Wright					SDG:	18-1	0018 -	Revise	d	
				Weston Solutions, Inc.					00951	31			
Final Report of Analysis			13702 (	13702 Coursey Blvd, Bldg 7 Suite A					ENVIRONMENTAL				
			Baton I	Rouge, L	A 70817	-1370		Sample Matrix:	SO				
LabID	SampleTy pe	ClientID	SampleDate	ReceiptDat	AnalysisDa	BatchID	Analyte	Method	Result	CU	CSU	MDA	ReportUnit
					10								-
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Thorium-234	EPA 901.1 Modified	3.12E+00	9.07E-01	9.21E-01	3.53E+00	pCi/g
18-10018-07	TRG	33-29-31-180808	08/08/18 00:00	10/3/2018	10/4/2018	18-10018	Thallium-208	EPA 901.1 Modified	2.45E+00	2.84E-01	3.11E-01	1.88E-01	pCi/g

**MEMO** 

DATE: June 27, 2019

TO: Keith Delhomme, Robert Sherman

FROM: Rick Haaker RF Hawher

SUBJECT: Review of Gamma Spectroscopy Data Package, 18-10018

The file evaluated was 18-10018.EDD-revised (1).xls. Don't know why it has that name.

This package consisted of 4 soil samples (1 of which was a replicate count that was analyzed twice for a total of 5 results), plus method blanks, lab control standards/spikes. All concentration units are in units of pCi/g, unless otherwise noted. The results are considered acceptable for use, except where noted otherwise. The following samples were analyzed by gamma spectroscopy.

SampleID_Table											
ClientID	LabID	Sample Type									
33-23-2-31-180807	18-10018-03	DUP									
33-23-2-31-180807	18-10018-04	DO									
33-26-31-180807	18-10018-05	TRG									
33-28-31-180808	18-10018-06	TRG									
33-29-31-180808	18-10018-07	TRG									

The data was delivered in the usual Microsoft excel data format, although the file might have been renamed at some point.

No isotopes were detected in the method blank samples at levels that exceeded the minimum detectable activity. Detected activity in the blanks is not a good thing.

The agreement between duplicate sample results was acceptable, except that thorium-234 exhibited a high degree of variability and thorium-234 values should be regarded as more uncertain than usual. The concentration of radium-226 in the duplicate sample was about 3.8 pCi/g. Radium-226 concentrations ranged up to about 53pCi/g in this dataset.

Thorium-234 results were considerably more precise than protactinium-234m results. The protactinium-234m results should not by themselves be considered reliable. Th-234 was reported as present at levels that exceed the minimum detectable activity in samples as follows. Results are in the units of pCi/g.

Detected Th234										
ClientID	Analyte	Results	MDAC							
33-23-2-31-180807	Thorium-234	8.69	6.77							
33-26-31-180807	Thorium-234	48.86	5.46							
33-28-31-180808	Thorium-234	3.64	2.07							

Ignoring protactinium-234m, all other uranium decay chain analytes were detected in all samples except as follows:

NonDetects6											
ClientID	Analyte	Result	MDAC	ReportUnits							
33-28-31-180808	Lead-210	1.06	1.4999	pCi/g							
33-29-31-180808	Lead-210	0.79	0.9481	pCi/g							
33-29-31-180808	Thorium-234	3.12	3.535	pCi/g							

This Eberline data package reports radium-226 as equal to bismuth-214, the radium-226 being assigned from the bismuth-214 values.

The degree of agreement between thorium-234 and radium-226 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that the thorium-234 results might be seriously biased by systematic error. The test statistic is the number of standard deviations by which the thorium-234 result exceeds the radium-226 result. If the test statistic is substantially less than zero, it implies that the reported radium-226 concentration is greater than the thorium-234 concentration. Gamma spectroscopy cannot detect thorium-230, so agreement between thorium-234 and radium-226 doesn't provide any information about equilibrium between thorium-230 and radium-226.

'Equilibrium" Th234 → Radium-226										
ClientID	Test Statistic	Disequilibrium Evidence								
33-23-2-31-180807	4.28	Strong								
33-23-2-31-180807	-0.62	Weak or none								
33-26-31-180807	-1.12	Weak or none								
33-28-31-180808	1.7	Weak or none								
33-29-31-180808	1.36	Weak or none								

The degree of agreement between radium-226 and lead-210 is summarized in the following table. The remark about strength of evidence of disequilibrium is subject to the caveat that there is no proficiency testing of radiochemistry laboratories for isotopes having gamma energies similar to those for lead-210. The test statistic is the number of standard deviations by which the radium-226 result exceeds the lead-210 result. If the test statistic is substantially less than zero, it implies that the reported lead-210 concentration is greater than the radium-226 concentration. Agreement between radium-226 and lead-210 doesn't provide *any* information about equilibrium between thorium-230 and radium-226.

EquilibriumPb210										
ClientID	Test Statistic	Disequilibrium Evidence								
33-23-2-31-180807	0.6	Weak or none								
33-23-2-31-180807	0.75	Weak or none								
33-26-31-180807	7.72	Strong								
33-28-31-180808	3.07	Strong								
33-29-31-180808	5.26	Strong								

One days elapsed from the date of receipt by Eberline to the date of analysis in their laboratory. Twenty-one days is recommended. The radium-226, lead-214 and bismuth-214 values reported may be somewhat lower than the true values and may be more uncertain than usual.

My impression is that the laboratory analyses are acceptable for use, but the thorium-234, radium-226, lead-214 and bismuth-214 values may be more uncertain than usual.

The maximum and estimated 99%UCLs (assuming normal statistics) for nuisance radionuclides in pCi/g, based on all prior datasets reviewed to this point are:

Analyte	Maximum	UCL99%
Actinium-228	2.37	2.2
Lead-212	8.45	3.25
Potassium-40	35.46	33.03
Thallium-208	2.12	1.98

For this dataset (data package), the following matrix of linear correlation coefficients was obtained for samples having a radium-226 concentration below 10pCi/g. Correlation coefficients can have a range between 1 and -1, and are a measure of tendency of pairs of *reported* isotopic concentrations to go up and down together in a linear fashion. These correlation coefficients are based on observations in the concentration range of interest to project engineers.

	Ac_228	Bi_214	Pb_210	Pb_212	Pb_214	K_40	Pa_234m	Ra_226	T1_208	Th_234
Ac_228	1.00	-0.94	-0.96	0.97	-0.92	-0.79	-0.72	-0.94	0.99	-0.71
Bi_214	-0.94	1.00	1.00	-0.93	0.99	0.95	0.86	1.00	-0.97	0.53
Pb_210	-0.96	1.00	1.00	-0.95	0.99	0.92	0.85	1.00	-0.98	0.57
Pb_212	0.97	-0.93	-0.95	1.00	-0.95	-0.84	-0.63	-0.93	0.98	-0.80
Pb_214	-0.92	0.99	0.99	-0.95	1.00	0.96	0.80	0.99	-0.96	0.59
K_40	-0.79	0.95	0.92	-0.84	0.96	1.00	0.80	0.95	-0.85	0.43
Pa_234m	-0.72	0.86	0.85	-0.63	0.80	0.80	1.00	0.86	-0.76	0.05
Ra_226	-0.94	1.00	1.00	-0.93	0.99	0.95	0.86	1.00	-0.97	0.53
T1_208	0.99	-0.97	-0.98	0.98	-0.96	-0.85	-0.76	-0.97	1.00	-0.68
Th 234	-0.71	0.53	0.57	-0.80	0.59	0.43	0.05	0.53	-0.68	1.00

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			Report To:						Wo	rk Order Detai	ils:		
Fhai	rline	<b>Analytical</b>	Jeff Wri	ght				SDG:	18-1	2112 F	REVISE	D	
			Weston	Solution	s, Inc.			Purchase Order:	00968	347			
Fina	l Rep	ort of Analysis	13702 C	oursey E	Blvd, Bldg	7 Suite	• <b>A</b>	Analysis Category:	ENVI	ENVIRONMENTAL			
	-	-	Baton R	ouge, LA	70817-1	370		Sample Matrix:	SO				
Lab ID	Sample Type	Client ID	Sample Date	Receipt Date	Analysis Date	Batch ID	Analyte	Method	Result	CU	CSU	MDA	Report Units
18-12112-01	LCS	KNOWN	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Cobalt-60	EPA 901.1 Modified	1.31E+02	5.10E+00			pCi/g
18-12112-01	LCS	KNOWN	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Cesium-137	EPA 901.1 Modified	8.26E+01	3.39E+00			pCi/g
18-12112-01	LCS	SPIKE	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Cobalt-60	EPA 901.1 Modified	1.59E+02	1.34E+01	1.57E+01	1.46E+00	pCi/g
18-12112-01	LCS	SPIKE	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Cesium-137	EPA 901.1 Modified	8.51E+01	7.78E+00	8.92E+00	1.47E+00	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	3.64E-02	6.74E-02	6.74E-02	1.20E-01	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	6.73E-02	3.94E-02	3.96E-02	2.96E-02	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	1.72E-01	1.76E-01	1.77E-01	3.79E-01	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	8.24E-01	1.59E+00	1.59E+00	3.10E+00	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	4.26E-01	3.69E-01	3.69E-01	6.58E-01	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	4.17E-02	3.15E-02	3.16E-02	5.46E-02	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	1.30E-02	4.24E-02	4.24E-02	6.62E-02	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	6.73E-02	3.94E-02	3.96E-02	2.96E-02	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	9.26E-01	3.57E-01	3.60E-01	6.74E-01	pCi/g
18-12112-02	MBL	BLANK	12/26/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	-1.73E-02	5.28E-02	5.28E-02	7.89E-02	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	1.79E+00	2.00E-01	2.20E-01	4.12E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	1.53E+00	1.68E-01	1.85E-01	1.88E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	2.87E+01	3.20E+00	3.52E+00	8.57E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	4.18E+00	4.85E+00	4.86E+00	7.89E+00	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	3.95E+00	1.52E+00	1.54E+00	2.31E+00	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	2.31E+00	2.62E-01	2.88E-01	2.24E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	1.64E+00	1.71E-01	1.91E-01	1.79E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	1.53E+00	1.68E-01	1.85E-01	1.88E-01	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	1.61E+00	1.13E+00	1.13E+00	1.85E+00	pCi/g
18-12112-03	DUP	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	1.05E+00	1.30E-01	1.41E-01	9.08E-02	pCi/g

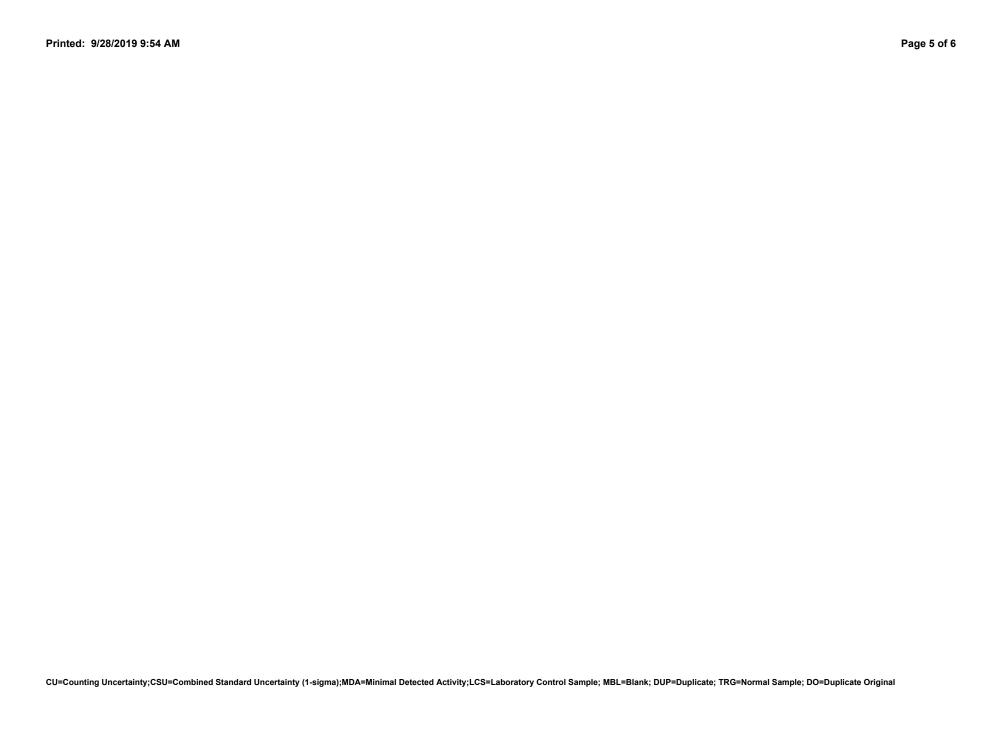
Printed: 9/28/2019 9:54 AM Page 2 of 6

			Report To:				Work Order Details:						
Eberline Analytical		Jeff Wright				SDG:	18-12112 REVISED						
Luci iiile Ailaiyticai			Weston Solutions, Inc.				Purchase Order:	0096847					
l Fina	l Rep	ort of Analysis		oursey E		7 Suite	A	Analysis Category:	: ENVIRONMENTAL				
	•	•	Baton Rouge, LA 70817-1370				Sample Matrix:	SO					
Lab ID	Sample Type	Client ID	Sample Date	Receipt Date	Analysis Date	Batch ID	Analyte	Method	Result	cu	CSU	MDA	Report Units
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	1.78E+00	2.13E-01	2.32E-01	3.38E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	1.48E+00	1.73E-01	1.89E-01	1.82E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	2.89E+01	3.21E+00	3.54E+00	8.64E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	1.22E+00	4.79E+00	4.79E+00	7.47E+00	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	2.51E+00	2.11E+00	2.12E+00	3.46E+00	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	2.10E+00	2.45E-01	2.68E-01	2.03E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	1.77E+00	1.95E-01	2.15E-01	2.45E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	1.48E+00	1.73E-01	1.89E-01	1.82E-01	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	2.22E+00	1.53E+00	1.53E+00	2.52E+00	pCi/g
18-12112-04	DO	32-06-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	1.22E+00	1.46E-01	1.59E-01	1.09E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	1.81E+00	2.72E-01	2.87E-01	4.93E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	1.63E+00	2.23E-01	2.38E-01	2.76E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	4.05E+01	6.75E+00	7.07E+00	1.52E+00	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	1.10E+01	6.62E+00	6.65E+00	1.04E+01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	1.15E+00	9.25E-01	9.27E-01	1.37E+00	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	2.21E+00	2.73E-01	2.96E-01	2.57E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	1.79E+00	1.94E-01	2.14E-01	2.86E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	1.63E+00	2.23E-01	2.38E-01	2.76E-01	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	1.17E+00	9.08E-01	9.10E-01	1.34E+00	pCi/g
18-12112-05	TRG	32-07-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	1.64E+00	2.99E-01	3.10E-01	3.68E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	1.68E+00	1.94E-01	2.12E-01	3.28E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	1.55E+00	1.84E-01	2.00E-01	2.03E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	2.90E+01	2.93E+00	3.29E+00	1.13E+00	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	1.96E+00	4.56E+00	4.56E+00	7.14E+00	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	1.31E+00	1.55E+00	1.55E+00	2.58E+00	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	1.70E+00	1.82E-01	2.02E-01	2.23E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	1.78E+00	1.60E-01	1.84E-01	1.78E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	1.55E+00	1.84E-01	2.00E-01	2.03E-01	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	1.34E+00	1.36E+00	1.36E+00	2.27E+00	pCi/g
18-12112-06	TRG	32-07-32-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	1.56E+00	1.76E-01	1.93E-01	1.63E-01	pCi/g

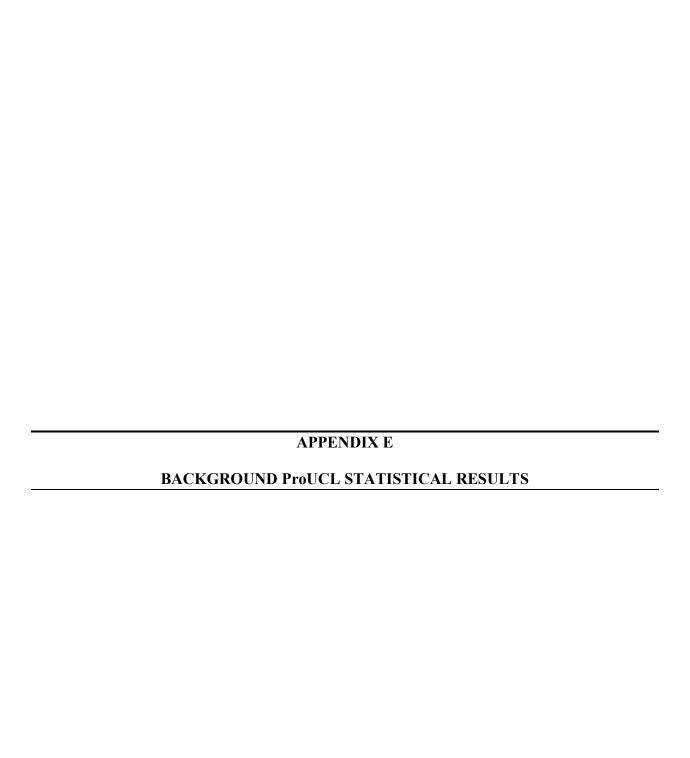
Printed: 9/28/2019 9:54 AM Page 3 of 6

			Report To:				Work Order Details:						
Eberline Analytical		Jeff Wright				SDG:	18-12112 REVISED						
			Weston Solutions, Inc.				Purchase Order:	00968	0096847				
Final Report of Analysis			13702 Coursey Blvd, Bldg 7 Suite A				Analysis Category:	ENVIRONMENTAL					
			Baton Rouge, LA 70817-1370				Sample Matrix:	SO					
Lab ID	Sample Type	Client ID	Sample Date	Receipt Date	Analysis Date	Batch ID	Analyte	Method	Result	CU	CSU	MDA	Report Units
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Actinium-228	EPA 901.1 Modified	2.61E+00	3.69E-01	3.93E-01	7.31E-01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Bismuth-214	EPA 901.1 Modified	2.11E+00	2.77E-01	2.98E-01	3.16E-01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Potassium-40	EPA 901.1 Modified	3.57E+01	4.03E+00	4.42E+00	1.86E+00	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Protactinium-234m	EPA 901.1 Modified	3.70E+00	1.02E+01	1.02E+01	1.65E+01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-210	EPA 901.1 Modified	2.34E+00	1.26E+00	1.27E+00	2.06E+00	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-212	EPA 901.1 Modified	2.79E+00	2.76E-01	3.11E-01	3.48E-01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Lead-214	EPA 901.1 Modified	2.09E+00	2.30E-01	2.54E-01	3.52E-01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Radium-226	EPA 901.1 Modified	2.11E+00	2.77E-01	2.98E-01	3.16E-01	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thorium-234	EPA 901.1 Modified	1.42E+00	1.27E+00	1.27E+00	2.12E+00	pCi/g
18-12112-07	TRG	32-08-31-180927	09/27/18 00:00	12/26/2018	12/27/2018	18-12112	Thallium-208	EPA 901.1 Modified	2.48E+00	3.35E-01	3.59E-01	3.39E-01	pCi/g

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Oll-Counting Uncontainty COUL-Counting Of Standard Uncontainty (Colors and Additional County of County October 1997).	
CU=Counting Uncertainty; CSU=Combined Standard Uncertainty (1-sigma); MDA=Minimal Detected Activity; LCS=Laboratory Control Sample; MBL=Blank; DUP=Duplicate; TRG=Normal Sample; DO=Duplicate Original	







# Section 33 Background Ra-226 BTV\_UTL95-95

#### **Background Statistics for Uncensored Full Data Sets**

#### **User Selected Options**

Date/Time of Computation ProUCL 5.15/16/2019 9:41:42 AM

From File WorkSheet.xls

Full Precision OFF

Confidence Coefficient 95%

Coverage 95%

New or Future K Observations 1

Number of Bootstrap Operations 2000

C0

#### **General Statistics**

Total Number of Observations	20	Number of Distinct Observations	18
Minimum	0.982	First Quartile	1.148
Second Largest	1.39	Median	1.22
Maximum	1.44	Third Quartile	1.333
Mean	1.223	SD	0.131
Coefficient of Variation	0.107	Skewness	-0.304
Mean of logged Data	0.196	SD of logged Data	0.11

#### Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL) 2.396 d2max (for USL) 2.557

#### **Normal GOF Test**

Shapiro Wilk GOF Test	0.965	Shapiro Wilk Test Statistic
Data appear Normal at 5% Significance Leve	0.905	5% Shapiro Wilk Critical Value
Lilliefors GOF Test	0.0965	Lilliefors Test Statistic
Data appear Normal at 5% Significance Leve	0.192	5% Lilliefors Critical Value

Data appear Normal at 5% Significance Level

#### **Background Statistics Assuming Normal Distribution**

95% UTL with 95% Coverage	1.537	90% Percentile (z)	1.391
95% UPL (t)	1.455	95% Percentile (z)	1.439
95% USL	1.558	99% Percentile (z)	1.528

#### Gamma GOF Test

Anderson-Darling Gamma GOF Test	0.31	A-D Test Statistic
Detected data appear Gamma Distributed at 5% Significance Leve	0.74	5% A-D Critical Value
Kolmogorov-Smirnov Gamma GOF Test	0.106	K-S Test Statistic
Detected data appear Gamma Distributed at 5% Significance Leve	0.193	5% K-S Critical Value

Detected data appear Gamma Distributed at 5% Significance Level

#### **Gamma Statistics**

k hat (MLE)	89.07	k star (bias corrected MLE)	75.74
Theta hat (MLE)	0.0137	Theta star (bias corrected MLE)	0.0161
nu hat (MLE)	3563	nu star (bias corrected)	3030
MLE Mean (bias corrected)	1.223	MLE Sd (bias corrected)	0.141

# Section 33 Background Ra-226 BTV\_UTL95-95 (continued)

#### **Background Statistics Assuming Gamma Distribution**

95% Wilson Hilferty (WH) Approx. Gamma UPL	1.469	90% Percentile	1.406
95% Hawkins Wixley (HW) Approx. Gamma UPL	1.471	95% Percentile	1.463
95% WH Approx. Gamma UTL with 95% Coverage	1.565	99% Percentile	1.574
95% HW Approx. Gamma UTL with 95% Coverage	1.569		
95% WH USL	1.59	95% HW USL	1.595

#### Lognormal GOF Test

Shapiro Wilk Lognormal GOF Test	0.953	Shapiro Wilk Test Statistic
Data appear Lognormal at 5% Significance Lev	0.905	5% Shapiro Wilk Critical Value
Lilliefors Lognormal GOF Test	0.104	Lilliefors Test Statistic
Data appear Lognormal at 5% Significance Lev	0.192	5% Lilliefors Critical Value

Data appear Lognormal at 5% Significance Level

#### **Background Statistics assuming Lognormal Distribution**

95% UTL with 95% Coverage	1.582	90% Percentile (z)	1.4
95% UPL (t)	1.477	95% Percentile (z)	1.457
95% USL	1.61	99% Percentile (z)	1.57

#### Nonparametric Distribution Free Background Statistics

Data appear Normal at 5% Significance Level

#### Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	20	95% UTL with 95% Coverage	1.44
Approx, f used to compute achieved CC	1.053	Approximate Actual Confidence Coefficient achieved by UTL	0.642
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	1.44	95% BCA Bootstrap UTL with 95% Coverage	1.44
95% UPL	1.438	90% Percentile	1.372
90% Chebyshev UPL	1.626	95% Percentile	1.393
95% Chebyshev UPL	1.808	99% Percentile	1.431
95% USL	1.44		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.

# Section 33 Background Gamma Count BTV\_UTL95-95

#### **Background Statistics for Uncensored Full Data Sets**

#### **User Selected Options**

Date/Time of Computation ProUCL 5.15/16/2019 9:39:56 AM

From File WorkSheet.xls

Full Precision OFF

Confidence Coefficient 95%

Coverage 95%

New or Future K Observations 1

Number of Bootstrap Operations 2000

C0

#### **General Statistics**

Total Number of Observations	20	Number of Distinct Observations	20
Minimum	30192	First Quartile	31525
Second Largest	32898	Median	32026
Maximum	32929	Third Quartile	32326
Mean	31873	SD	725.5
Coefficient of Variation	0.0228	Skewness	-0.743
Mean of logged Data	10.37	SD of logged Data	0.023

#### Critical Values for Background Threshold Values (BTVs)

Tolerance Factor K (For UTL) 2.396 d2max (for USL) 2.557

#### **Normal GOF Test**

Shapiro Wilk Test Statistic	0.951	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.905	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.114	Lilliefors GOF Test
5% Lilliefors Critical Value	0.192	Data appear Normal at 5% Significance Level

#### Data appear Normal at 5% Significance Level

#### **Background Statistics Assuming Normal Distribution**

95% UTL with 95% Coverage	33612	90% Percentile (z)	32803
95% UPL (t)	33159	95% Percentile (z)	33067
95% USL	33728	99% Percentile (z)	33561

#### Gamma GOF Test

A-D Test Statistic	0.364	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.118	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.193	Detected data appear Gamma Distributed at 5% Significance Level

#### Detected data appear Gamma Distributed at 5% Significance Level

#### **Gamma Statistics**

1708	k star (bias corrected MLE)	2010	k hat (MLE)
18.66	Theta star (bias corrected MLE)	15.86	Theta hat (MLE)
68331	nu star (bias corrected)	80388	nu hat (MLE)
771.2	MLE Sd (bias corrected)	31873	MLE Mean (bias corrected)

# Section 33 Background Gamma Count BTV\_UTL95-95 (continued)

#### **Background Statistics Assuming Gamma Distribution**

95% Wilson Hilferty (WH) Approx. Gamma UPL	33178	90% Percentile	32865
95% Hawkins Wixley (HW) Approx. Gamma UPL	33180	95% Percentile	33152
95% WH Approx. Gamma UTL with 95% Coverage	33648	99% Percentile	33695
95% HW Approx. Gamma UTL with 95% Coverage	33652		
95% WH USL	33769	95% HW USL	33775

#### **Lognormal GOF Test**

Shapiro Wilk Lognormal GOF Test	0.947	Shapiro Wilk Test Statistic
Data appear Lognormal at 5% Significance Le	0.905	5% Shapiro Wilk Critical Value
Lilliefors Lognormal GOF Test	0.118	Lilliefors Test Statistic
Data appear Lognormal at 5% Significance Le	0.192	5% Lilliefors Critical Value

Data appear Lognormal at 5% Significance Level

#### **Background Statistics assuming Lognormal Distribution**

95% UTL with 95% Coverage	33667	90% Percentile (z)	32816
95% UPL (t)	33188	95% Percentile (z)	33091
95% USL	33791	99% Percentile (z)	33613

#### Nonparametric Distribution Free Background Statistics

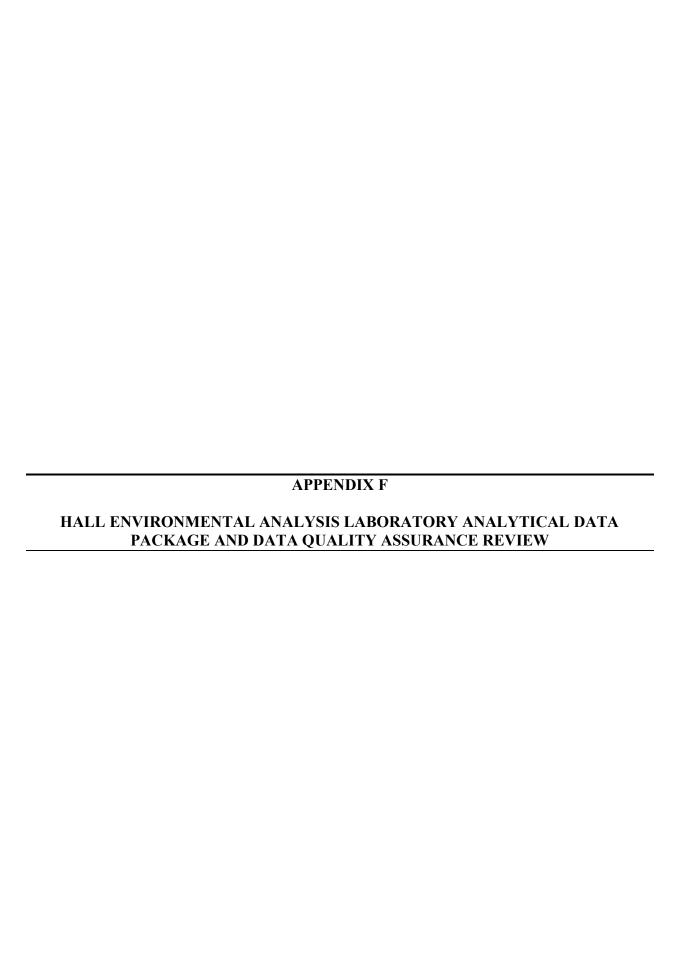
Data appear Normal at 5% Significance Level

#### Nonparametric Upper Limits for Background Threshold Values

Order of Statistic, r	20	95% UTL with 95% Coverage	32929
Approx, f used to compute achieved CC	1.053	Approximate Actual Confidence Coefficient achieved by UTL	0.642
		Approximate Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	32929	95% BCA Bootstrap UTL with 95% Coverage	32929
95% UPL	32927	90% Percentile	32665
90% Chebyshev UPL	34104	95% Percentile	32900
95% Chebyshev UPL	35114	99% Percentile	32923
95% USL	32929		

Note: The use of USL tends to yield a conservative estimate of BTV, especially when the sample size starts exceeding 20. Therefore, one may use USL to estimate a BTV only when the data set represents a background data set free of outliers and consists of observations collected from clean unimpacted locations.

The use of USL tends to provide a balance between false positives and false negatives provided the data represents a background data set and when many onsite observations need to be compared with the BTV.



## DATA QUALITY ASSURANCE REVIEW

SITE NAME	Tronox Secti	on 32/33 Mine		
WORK ORDE	R NUMBER	20600.012.001.1045.06	TDD NUMBER	0001/17-035
PROJECT NU	MBER		SDG NUMBER	1811684
20600.012.001.104	5.06, SDG No st (TAL) metal	. 1811684, Tronox Section	on 32/33 Mine. Nir	for Work Order Number ne samples were analyzed for lysis Laboratory, Inc. Sample
		SAMPLE NUM	BERS	
32-01-31-181103-N	<u> </u>	32-02-31-181103-M	32-03-31-1811	03-M
32-03-32-181103-N		33-01-31-181103-M	33-02-31-1811	03-M
33-03-31-181103-N		33-04-31-181103-M	33-05-31-1811	03-M
USEPA National F National Function Laboratory Progra (April, 2016), Qua	unctional Guide al Guidelines f um National Fu lity Assurance/9 ocol for Holdin	elines for Organic Superfu for Inorganic Superfund nctional Guidelines for H Quality Control Guidance g Times, Blanks, and V	nd Methods Data Ro Data Review (Janu High Resolution Sup for Removal Activi	tions were achieved, following eview (January, 2017), USEPA contract perfund Methods Data Review ties (September, 2011), and/or April 13, 1989). Specific data
REVIEWER	Gloria J. Swi	talski	DATE	June 21, 2019

#### **Data Qualifiers**

Data Qualifier Definitions were supplied by the Office of Solid Waste and Emergency Response (September 1989) and are included in the Functional Guidelines. Data qualifiers may be combined (UJ, QJ) with the corresponding combination of meanings. Additional qualifiers may be added to provide additional, more specific information (JL, UB, QJK), modifying the meaning of the primary qualifier. Additional qualifiers utilized by WESTON are H, L, K, B, and Q.

U - The material was analyzed for, but was not detected. The associated numerical value is the sample quantitation or detection limit, which has been adjusted for sample weight/sample volume, extraction volume, percent solids, sample dilution or other analysis specific parameters.

An additional qualifier, "B", may be appended to indicate that while the analyte was detected in the sample, the presence of the analyte may be attributable to blank contamination and the analyte is therefore considered undetected with the sample detection or quantitation limit for the analyte being elevated.

J - The analyte was analyzed for, but the associated numerical value may not be consistent with the amount actually present in the environmental sample or may not be consistent with the sample detection or quantitation limit. The value is an estimated quantity. The data should be seriously considered for decision-making and are usable for many purposes.

An additional qualifier will be appended to the "J" qualifier that indicates the bias in the reported results:

- L Low bias
- H High bias
- K Unknown bias
- Q The reported concentration is less than the sample quantitation limit for the specific analyte in the sample.

The L and H qualifier will only be employed when a single qualification is required. When more than one quality control parameter affects the analytical result and a conflict results in assigning a bias, the result will be flagged JK.

- R Quality Control indicates that data are unusable for all purposes. The analyte was analyzed for, but the presence or absence of the analyte has not been verified. Resampling and reanalysis are necessary for verification to confirm or deny the presence of an analyte.
- N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."

#### METALS DATA EVALUATION

#### 1. Analytical Method:

Samples were prepared and analyzed for metals and mercury using the procedures specified in SW-846 Methods 6010B and 7471.

#### 2. Holding Times:

All samples met established holding time criteria of 180 days for ICP metals and 28 days for mercury. No qualifications are placed on the data.

#### 3. Initial Calibration:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

#### 4. Continuing Calibration:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

#### 5. CRDL Standard:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

#### 6. Blanks:

#### A. Laboratory Blanks:

Target analytes were detected in a method blank at concentrations that warrant blank action. Details are noted below:

ANALYTE/BLANK #	CONCENTRATION	AFFECTED SAMPLES
Sodium/MB-41583	31 mg/kg	U @ reported concentration, All

MB = Method Blank

#### B. Field Blanks:

No field blank samples were submitted with this analytical package. No qualifications are placed on the data.

#### 7. ICP Interference Check:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

#### 8. Laboratory Control Sample (LCS):

The laboratory analyzed LCS and recoveries for these analyses were within the control limits provided. No qualifications are placed on the data.

### 9. Duplicate Sample Analysis:

#### A. Laboratory Duplicate Analysis:

No sample from this analytical package underwent matrix spike/matrix spike duplicate analysis for the soil matrix for ICP metals and mercury. No qualifications are placed on the data.

#### B. Field Duplicate Analysis:

The following sample pair was submitted as field duplicates for the soil matrix for ICP metals and mercury: 32-03-31-181103-M/32-03-32-181103-M. The relative percent difference (RPD) values for the field duplicate sample analysis were within the QC criteria of less than 30% for aqueous samples and less than 50% for soil samples for concentrations greater than five times the practical quantitation limit (PQL). For sample concentrations less than five times the PQL, the absolute difference between the samples is less than two times the PQL for aqueous samples or less than 3.5 times the PQL for the soil samples. All QC criteria were met. No qualifications are placed on the data.

#### 10. Matrix Spikes/Matrix Spike Duplicates (MS/MSD):

No sample from this analytical package underwent matrix spike/matrix spike duplicate analysis for the soil matrix for ICP metals and mercury. No qualifications are placed on the data.

#### 11. ICP Serial Dilution:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

#### 12. Sample Quantitation and Reporting Limits:

Level 4 data validation is not being performed on this data set at this time. In the event that level 4 validation is performed, this validation report will be revised to include the level 4 findings. No qualifications are placed on the data.

Some ICP metals analytes in all samples were analyzed at a 2, 5, 100, or 200-fold dilution. PQL for these analytes in these samples were elevated as a result of the dilutions performed.

## 13. Laboratory Contact

No laboratory contact was required.

### 14. Overall Assessment:

The sodium result in all soil samples was qualified as undetected due to method blank action.

The analytical data is acceptable for use with the qualifications listed above.

#### Lab Order **1811684**

Hall Environmental Analysis Laboratory, Inc.

Date Reported: 12/19/2018

CLIENT: Weston Solutions, Inc.

Client Sample ID: 32-01-31-181103-M

**Project:** 1 Weston 04217013 181108 003

Collection Date: 11/3/2018

**Lab ID:** 1811684-001

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY						Analyst:	rde
Mercury	ND	0.033		mg/Kg	1	11/27/2018 5:08:28 PM	41736
EPA METHOD 6010B: SOIL METALS						Analyst:	rde
Aluminum	11000	290		mg/Kg	100	12/6/2018 1:31:17 PM	41583
Antimony	ND	2.4		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Arsenic	3.3	2.4		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Barium	150	0.098		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Beryllium	0.56	0.15		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Cadmium	ND	0.098		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Calcium	22000	120		mg/Kg	5	12/4/2018 3:31:51 PM	41583
Chromium	4.8	0.29		mg/Kg	. 1	12/4/2018 3:23:44 PM	41583
Cobalt	3.1	0.29		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Copper	4.4	0.29		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Iron	12000	240		mg/Kg	100	12/6/2018 1:31:17 PM	41583
Lead	4.3	0.24		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Magnesium	3200	120		mg/Kg	5	12/4/2018 3:31:51 PM	41583
Manganese	140	0.098		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Nickel	5.0	0.49		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Potassium	2900	240		mg/Kg	5	12/4/2018 3:31:51 PM	41583
Selenium	ND	2.4		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Silver	ND	0.24		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Sodium	<sub>180</sub> U	120		mg/Kg	5	12/4/2018 3:31:51 PM	41583
Thallium	ND	2.4		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Uranium	ND	4.9		mg/ <b>Kg</b>	1	12/4/2018 3:23:44 PM	41583
Vanadium	16	2.4		mg/Kg	1	12/4/2018 3:23:44 PM	41583
Zinc	24	2.4		mg/Kg	1	12/10/2018 6:20:34 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 1 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

Lab Order 1811684

## Hall Environmental Analysis Laboratory, Inc.

Date Reported: 12/19/2018

CLIENT: Weston Solutions, Inc.

**Client Sample ID:** 32-02-31-181103-M

Project:

1 Weston 04217013 181108 003

Collection Date: 11/3/2018

Lab ID: 1

1811684-002

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY					Analyst	rde
Mercury	ND	0.033	mg/Kg	1	11/27/2018 5:10:15 PM	41736
EPA METHOD 6010B: SOIL METALS					Analyst	rde
Aluminum	25000	580	mg/Kg	200	12/6/2018 3:32:13 PM	41583
Antimony	ND	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Arsenic	4.9	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Barium	110	0.19	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Beryllium	1.1	0.29	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Cadmium	ND	0.19	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Calcium	6000	48	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Chromium	12	0.58	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Cobalt	6.3	0.58	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Copper	10	0.58	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Iron	22000	480	mg/Kg	200	12/10/2018 5:44:19 PM	41583
Lead	6.0	0.48	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Magnesium	4800	48	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Manganese	220	0.19	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Nickel	9.7	0.96	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Potassium	4500	96	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Selenium	ND	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Silver	ND	0.48	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Sodium	190	<b>U</b> 48	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Thallium	ND	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Uranium	ND	9.6	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Vanadium	34	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583
Zinc	49	4.8	mg/Kg	2	12/10/2018 6:22:33 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 2 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

#### Lab Order **1811684**

Date Reported: 12/19/2018

# Hall Environmental Analysis Laboratory, Inc.

CLIENT: Weston Solutions, Inc.

Client Sample ID: 32-03-31-181103-M

**Project:** 1 Weston 04217013 181108 003

Collection Date: 11/3/2018

Lab ID:

1811684-003

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY						Analyst	rde
Mercury	ND	0.033		mg/Kg	1	11/27/2018 5:11:56 PM	41736
EPA METHOD 6010B: SOIL METALS						Analyst	rde
Aluminum	12000	300		mg/Kg	. 100	12/6/2018 1:45:53 PM	41583
Antimony	ND	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Arsenic	ND	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Barium	150	0.20		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Beryllium	0.66	0.30		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Cadmium	ND	0.20		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Calcium	13000	120		mg/Kg	5	12/10/2018 6:34:49 PM	41583
Chromium	2.6	0.59		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Cobalt	2.6	0.59		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Copper	4.1	0.59		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Iron	11000	250		mg/Kg	100	12/6/2018 1:45:53 PM	41583
Lead	6.6	0.49		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Magnesium	3400	49		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Manganese	240	0.20		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Nickel	3.6	0.98		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Potassium	2700	98		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Selenium	ND	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Silver	ND .	0.49		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Sodium	140 <b>U</b>	49		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Thallium	ND	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Uranium	21	9.8		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Vanadium	23	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583
Zinc	17	4.9		mg/Kg	2	12/10/2018 6:32:56 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 3 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

#### Lab Order **1811684**

Date Reported: 12/19/2018

## Hall Environmental Analysis Laboratory, Inc.

CLIENT: Weston Solutions, Inc.

Client Sample ID: 32-03-32-181103-M

1 Weston 04217013 181108 003

Collection Date: 11/3/2018

**Lab ID:** 1811684-004

**Project:** 

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY						Analyst	rde
Mercury	ND	0.032		mg/Kg	1	11/27/2018 5:13:36 PM	41736
EPA METHOD 6010B: SOIL METALS						Analyst	rde
Aluminum	13000	290		mg/Kg	100	12/6/2018 1:47:43 PM	41583
Antimony	ND	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Arsenic	ND	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Barium	250	0.19		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Beryllium	0.72	0.29		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Cadmium	ND	0.19		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Calcium	12000	120		mg/Kg	5	12/10/2018 6:38:31 PM	41583
Chromium	2.8	0.58		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Cobalt	2.8	0.58		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Copper	5.5	0.58		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Iron	11000	240		mg/Kg	100	12/6/2018 1:47:43 PM	41583
Lead	6.1	0.48		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Magnesium	3600	48		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Manganese	240	0.19		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Nickel	4.0	0.96		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Potassium	2700	96		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Selenium	ND	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Silver	ND	0.48		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Sodium	140 <b>U</b>	48		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Thallium	ND	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Uranium	ND	9.6		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Vanadium	15	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583
Zinc	14	4.8		mg/Kg	2	12/10/2018 6:36:41 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 4 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

#### Lab Order 1811684

Date Reported: 12/19/2018

## Hall Environmental Analysis Laboratory, Inc.

**CLIENT:** Weston Solutions, Inc.

**Client Sample ID:** 33-01-31-181103-M

**Project:** 1 Weston 04217013 181108 003

Collection Date: 11/3/2018

Lab ID: 1811684-005

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	F	QL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY							Analyst:	rde
Mercury	ND	0	.033		mg/Kg	1	11/27/2018 5:15:17 PM	41736
EPA METHOD 6010B: SOIL METALS							Analyst:	rde
Aluminum	8300		300		mg/Kg	100	12/6/2018 1:49:22 PM	41583
Antimony	ND		2.5		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Arsenic	2.5		2.5		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Barium	41	0	.098		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Beryllium	0.36		0.15		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Cadmium	ND	0	.098		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Calcium	2800		25		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Chromium	1.7		0.30		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Cobalt	1.8		0.30		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Copper	2.7		0.30		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Iron	8700		250		mg/Kg	100	12/6/2018 1:49:22 PM	41583
Lead	3.9		0.25		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Magnesium	2100		25		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Manganese	76	C	.098		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Nickel	2.7		0.49		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Potassium	1600		49		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Selenium	12		2.5		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Silver	ND		0.25		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Sodium	69	V	25		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Thallium	ND		2.5		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Uranium	ND		4.9		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Vanadium	23		2.5		mg/Kg	1	12/4/2018 3:40:11 PM	41583
Zinc	11		2.5		mg/Kg	1	12/10/2018 6:40:21 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 5 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

### Lab Order 1811684

Hall Environmental Analysis Laboratory, Inc.

Date Reported: 12/19/2018

**CLIENT:** Weston Solutions, Inc.

**Client Sample ID:** 33-02-31-181103-M

**Project:** 1 Weston 04217013 181108 003

Collection Date: 11/3/2018

Lab ID:

1811684-006

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual	Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY						Analyst	rde
Mercury	ND	0.033		mg/Kg	1	11/27/2018 5:16:58 PM	41736
EPA METHOD 6010B: SOIL METALS						Analyst	rde
Aluminum	22000	290		mg/Kg	100	12/6/2018 1:50:59 PM	41583
Antimony	ND	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Arsenic	5.5	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Barium	81	0.20		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Beryllium	0.92	0.29		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Cadmium	ND	0.20		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Calcium	7800	49		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Chromium	11	0.59		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Cobalt	6.2	0.59		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Copper	11	0.59		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Iron	24000	240		mg/Kg	100	12/6/2018 1:50:59 PM	41583
Lead	7.3	0.49		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Magnesium	4600	49		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Manganese	170	0.20		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Nickel	13	0.98		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Potassium	4200	98		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Selenium	ND	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Silver	ND	0.49		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Sodium	200 <b>V</b>	49		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Thallium	ND	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Uranium	ND	9.8		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Vanadium	30	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583
Zinc	50	4.9		mg/Kg	2	12/10/2018 6:42:18 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 6 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

### Lab Order 1811684

Date Reported: 12/19/2018

## Hall Environmental Analysis Laboratory, Inc.

CLIENT: Weston Solutions, Inc.

Client Sample ID: 33-03-31-181103-M

Project:

1 Weston 04217013 181108 003

Collection Date: 11/3/2018

**Lab ID:** 1811684-007

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual Units	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY					Analyst	rde
Mercury	ND	0.033	mg/Kg	1	11/27/2018 5:22:14 PM	41736
EPA METHOD 6010B: SOIL METALS					Analyst	rde
Aluminum	25000	590	mg/Kg	200	12/6/2018 4:48:22 PM	41583
Antimony	ND	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Arsenic	5.7	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Barium	79	0.20	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Beryllium	1.1	0.30	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Cadmium	ND	0.20	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Calcium	6400	49	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Chromium	14	0.59	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Cobalt	6.5	0.59	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Copper	12	0.59	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Iron	26000	490	mg/Kg	200	12/6/2018 4:48:22 PM	41583
Lead	6.8	0.49	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Magnesium	5200	49	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Manganese	180	0.20	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Nickel	14	0.99	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Potassium	5300	99	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Selenium	ND	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Silver	ND	0.49	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Sodium	290 🔰	49	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Thallium	ND	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Uranium	ND	9.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Vanadium	37	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583
Zinc	54	4.9	mg/Kg	2	12/10/2018 6:46:14 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
  - S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 7 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

#### Lab Order 1811684

Date Reported: 12/19/2018

Hall Environmental Analysis Laboratory, Inc.

CLIENT: Weston Solutions, Inc.

**Client Sample ID:** 33-04-31-181103-M

Project: 1 We

1 Weston 04217013 181108 003

**Collection Date:** 11/3/2018

Lab ID:

1811684-008

Matrix: SOIL

Received Date: 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual U	Jnits	DF	Date Analyzed	Batch
EPA METHOD 7471: MERCURY						Analyst:	rde
Mercury	ND	0.033	n	ng/Kg	1	11/27/2018 5:23:56 PM	41736
EPA METHOD 6010B: SOIL METALS						Analyst:	rde
Aluminum	23000	290	n	ng/Kg	100	12/6/2018 1:54:25 PM	41583
Antimony	ND .	4.8	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Arsenic	6.3	4.8	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Barium	70	0.19	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Beryllium	1.0	0.29	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Cadmium	ND	0.19	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Calcium	6700	48	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Chromium	12	0.58	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Cobalt	6.3	0.58	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Copper	12	0.58	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Iron	25000	480	n	ng/Kg	200	12/6/2018 4:52:12 PM	41583
Lead	7.7	0.48	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Magnesium	4800	48	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Manganese	170	0.19	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Nickel	14	0.97	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Potassium	5200	97	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Selenium	ND	4.8	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Silver	ND	0.48	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Sodium	180 <b>V</b>	48	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Thallium	ND	4.8	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Uranium	ND	9.7	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Vanadium	33	4.8	· n	ng/Kg	2	12/10/2018 6:50:05 PM	41583
Zinc	55	4.8	n	ng/Kg	2	12/10/2018 6:50:05 PM	41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- \* Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 8 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified

#### Lab Order 1811684

Date Reported: 12/19/2018

## Hall Environmental Analysis Laboratory, Inc.

**CLIENT:** Weston Solutions, Inc.

**Client Sample ID:** 33-05-31-181103-M

**Project:** 1 Weston 04217013 181108 003

Collection Date: 11/3/2018

**Lab ID:** 1811684-009

Matrix: SOIL

**Received Date:** 11/9/2018 8:40:00 AM

Analyses	Result	PQL	Qual Units	DF Date Ana	nlyzed	Batch
EPA METHOD 7471: MERCURY					Analyst	: rde
Mercury	ND	0.033	mg/Kg	1 11/27/201	8 5:25:38 PM	41736
EPA METHOD 6010B: SOIL METALS					Analyst	: rde
Aluminum	22000	290	mg/Kg	100 12/6/2018	1:56:09 PM	41583
Antimony	ND	4.8	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Arsenic	6.5	4.8	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Barium	56	0.19	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Beryllium	0.97	0.29	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Cadmium	ND	0.19	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Calcium	5700	48	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Chromium	12	0.58	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Cobalt	8.6	1.4	mg/Kg	5 12/12/201	8 10:54:27 Al	M 41583
Copper	11	0.58	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Iron	26000	480	mg/Kg	200 12/6/2018	4:54:01 PM	41583
Lead	8.4	0.48	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Magnesium	4000	48	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Manganese	160	0.19	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Nickel	14	0.96	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Potassium	4400	96	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Selenium	ND	12	mg/Kg	5 12/12/201	8 10:54:27 Al	M 41583
Silver	ND	0.48	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Sodium	170 <b>V</b>	48	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Thallium	ND	4.8	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Uranium	ND	9.6	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Vanadium	33	4.8	mg/Kg	2 12/10/201	8 7:02:56 PM	41583
Zinc	66	12	mg/Kg	5 12/12/201	8 10:54:27 AI	VI 41583



Refer to the QC Summary report and sample login checklist for flagged QC data and preservation information.

- Value exceeds Maximum Contaminant Level.
- D Sample Diluted Due to Matrix
- H Holding times for preparation or analysis exceeded
- ND Not Detected at the Reporting Limit
- PQL Practical Quanitative Limit
- S % Recovery outside of range due to dilution or matrix
- B Analyte detected in the associated Method Blank
- E Value above quantitation range
- J Analyte detected below quantitation limits Page 9 of 14
- P Sample pH Not In Range
- RL Reporting Detection Limit
- W Sample container temperature is out of limit as specified



## Appendix G

## Human Health and Ecological Streamlined Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

# 1 HUMAN HEALTH AND ECOLOGICAL STREAMLINED RISK EVALUATION

Uranium mine wastes are known to contain elevated levels of radium-226 (Ra-226) and associated progeny. Radium-226, a daughter product in the uranium-238 (U-238) decay chain, has been found to be the predominant contributor of radiological risk to human health and is the radionuclide for which historical cleanup limits have been specified at uranium mines. Radium-226 has been identified as a human health contaminant of potential concern (COPC) at the Sections 32 and 33 Mines Site to be addressed as part of cleanup actions. Radium is formed when uranium and thorium undergo natural decay in the environment. During the decay processes, alpha, beta, and gamma radiation are released. Results of Site investigations have indicated the need for a response action to control releases and prevent human exposure to radiation at the Site. Under a current residential scenario, Table G-1 summarizes the radionuclide analytical results and the human health risks associated with Ra-226 and other isotopes of the uranium-235 (U-235) and U-238 decay chains at the Sections 32 and 33 Mines Site, assuming no action is taken. EPA considered contributions to human health and ecological risks from all of the isotopes in the U-238 and U-235 decay chains. Note that the risk estimates presented in Table G-1 also include contribution of the background level of Ra-226 (1.5 picocuries per gram [pCi/g]). The estimated cancer risk associated with nearly all of the waste soil currently present at the Sections 32 and 33 Mines Site exceeds the EPA 10<sup>-4</sup> overall cancer risk threshold for the residential scenario; therefore, it is anticipated that action will be taken to reduce the human health risk. Note that the EPA default value for lifetime exposure for a residential land-use scenario, used in these calculations, is 26 years, including 6 years as a child and 20 years as an adult. The Navajo Nation government, however, leases Navajo allotment lands to eligible Navajo for residential purposes for 75 years. Substituting 75 years (6 years as a child and 69 years as an adult) for lifetime residential exposure in the PRG Calculator would have the effect of increasing the total cancer risks in surface and subsurface soil approximately three-fold, exhibiting an even greater need for a response action to reduce the human health risk.



1 of 19 TDD No. 0001/17-045

## Appendix G (Continued)

### Human Health and Ecological Streamlined Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

With the exception of uranium, non-radionuclide metals were either within background levels or below their respective human health screening levels (Table G-2). Uranium had one detected concentration (21 mg/kg) which is above the residential screening level (RSL) at a Target Hazard Quotient (THQ) of 1 (16 mg/kg). Table G-3 presents the non-cancer Hazard Index (HI) for the child and adult resident based on this single uranium detection (32-03-31-181103-M). The HI values were 1 and 0.1 for child and adult residents, respectively. Given that uranium is the only non-radionuclide metal contaminant of potential concern (COPC), there are no cumulative effects on target organs that would exceed the EPA point of departure of 1 (when rounding to one significant figure). Tables G-4, G-5 and G-6 present the results of an ecological risk evaluation for the Sections 32 and 33 Mines Site. When dealing with noncarcinogens, EPA guidance states that the noncancer averaging time (AT) is to be set at the same length as the exposure duration (ED), essentially cancelling out the AT and ED terms in the RSL equation. As a result, increasing lifetime exposure to 75 years, to accommodate a Navajo-specific lifeway as described above, would yield the same non-cancer hazard index. Regardless, it is anticipated that site actions to address radionuclide exposure by human receptors will be protective for exposure of human receptors to both radionuclides and non-radionuclide chemicals due to the colocation of uranium and its decay-chain progeny (includes Ra-226).

The following sections describe the streamlined risk evaluation (SRE) process. Based on this evaluation, it is concluded that Site actions are required to address radiological human health risks at the Sections 32 and 33 Mines Site, and that actions taken to address radionuclides will be protective for non-radionuclide chemical exposure and for exposure of ecological receptors.

# 2 ANALYTICAL DATA USED IN STREAMLINED RISK EVALUATION CALCULATIONS

Analytical results of soil samples collected during the Removal Site Evaluation at the Sections 32 and 33 Mine Site (WESTON, 2019) served as input data for the human health and ecological SRE. These samples were analyzed for radioisotopes (i.e., Ra-226) via gamma spectroscopy in the field using an on-site Multi-Channel Analyzer (MCA). Six of the surface and one of the subsurface samples were also analyzed in an off-site laboratory as verification of the on-site MCA results. If



2 of 19 TDD No. 0001/17-045

#### Human Health and Ecological Streamlined Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

both an off-site laboratory result and on-site MCA result was available, the off-site laboratory result was used in the SRE.

Soil samples were collected from August through November 2018 and analyzed by gamma spectroscopy to confirm the gamma readings and to estimate the depth of contamination. Five surface (0-6 inch below ground surface [bgs]) grab soil samples plus one duplicate sample and three surface composite soil samples were collected from the Site and were analyzed via gamma spectroscopy (Section 5.5.3). Nine surface soil samples were collected from the Section 32 and 33 Mine Sites (Section 32 = 3; Section 33 = 6). Three surface soil samples plus one duplicate were collected from the yards of residences in Section 32 (Figure 1-13). Three grab surface soil samples were collected up-gradient from the mine in Section 33 (Figure 1-14). Three composite surface soil samples were collected from waste piles in the fenced mine footprint area in Section 33 (Figure 1-14). To determine vertical extent of contamination, subsurface soil samples (12-18 inch bgs) were collected from 5 locations with one duplicate in Section 32 (Figure 1-13). Subsurface soil samples were collected from 4 locations in the fenced mine footprint area of Section 33 (Figure 1-14); subsurface sample locations did not include the waste pile areas. The analytical results used in the evaluations are summarized in Tables 1-2 and 1-3.

In November 2018, eight surface soil samples plus one duplicate were collected from the Sections 32 and 33 Mines Site for analysis of TAL (EPA Method 6010B) metals plus uranium. Three surface soil samples plus one duplicate were collected from Section 32 (Figure 1-13) and five surface soil samples were collected from Section 33 (Figure 1-14). The metals analysis was performed to evaluate if common mining-related heavy metals present a potential risk to human health or the environment. A minimal number of samples were analyzed for TAL metals and uranium metals due to consistent geochemistry and limited historical processing for metals other than uranium as product. There is no history of non-uranium metals mining in the ALSD. The analytical results used in the TAL metals evaluation are summarized in Table 1-4.

Additionally, EPA collected eight vegetative metals uptake samples in order to determine the current vegetative nutrient values and uptake of potential hazardous constituents available to grazing animals (domesticated animals and wildlife). Surface vegetation samples were collected



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from the eight vegetation transects identified during the Natural Resources Evaluation (NV5, 2019), which included three transects in the Great Basin Desert Scrub community type (dominated by four-wing saltbush/kochia/gumweed/various weeds), two transects in the Great Basin Desert Scrub community type (dominated by four-wing saltbush/blue grama/galleta/western wheat grass), one transect in the Coniferous Woodland community type (dominated by one-seed juniper/pinyon pine/Bigelow sage), and two transects from the Arroyo Riparian community type (dominated by rabbitbrush/saltbush/galleta). The analytical results are presented in Table G-7. Native plant tissue samples were analyzed for nutrients (iron, zinc, copper, and manganese) and for toxic metals (molybdenum, uranium, vanadium, and selenium).

# 3 SCREENING TO IDENTIFY CONTAMINANTS OF POTENTIAL CONCERN

For the human health screening risk evaluation, the non-radionuclide sampling results were screened against the November 2019 EPA [2019a] residential Regional Screening Levels (RSLs) (https://www.epa.gov/risk/regional-screening-levels-rsls), the New Mexico Environment Department (NMED, 2019) generic soil screening levels (SSLs) for residential land use, and the local background concentrations to identify human health non-radionuclide COPCs. Table G-2 summarizes this screening process for soil at the Sections 32 and 33 Mines Site, showing contaminants that were considered, the minimum and maximum concentrations, associated RSLs and SSLs, and background concentrations, and either identifies each contaminant as a COPC or explains why it was screened from consideration. Screening levels were adjusted to a target cancer risk of 10<sup>-6</sup> and a target hazard quotient of 0.1 to account for additive risk. Aluminum, arsenic, cobalt, iron, manganese, and uranium concentrations exceeded the most stringent of their respective RSLs.

Site-specific background levels were not available. Background levels for the metals were obtained from literature values for New Mexico (EPA, 2007) and the Western United States (Shacklette and Boernren, 1984). These background levels are also considered in the risk evaluation. Background information is important to risk managers because the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) program, generally, does



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not clean up to concentrations below natural or anthropogenic background levels (EPA, 2002). Aluminum, cobalt, and manganese concentrations do not exceed background levels. While the maximum concentrations for arsenic (6.5 mg/kg) and iron (26,000 mg/kg) exceed their respective mean background concentrations (5.9 and 20,898 mg/kg, respectively), they do not exceed two times their respective means. Arsenic and iron are considered to be representative of background. Uranium was detected in one of nine samples with a concentration of 21 mg/kg. This value exceeds the mean background concentration (2.5 mg/kg) and is above the EPA residential RSL based on target hazard quotient of 1 (16 mg/kg). Therefore, uranium is carried through the risk evaluation as a COPC and discussed in the following section.

A separate screening procedure was performed in the ecological streamlined risk evaluation. The results of the screening level ecological risk characterization are included in Table G-4 for radionuclides and Table G-5 for metals. Literature-based ecological screening benchmark values for direct contact and food-chain evaluations are used to characterize potential ecological effects. The ecological streamlined risk evaluation is detailed in Section 5.

#### 4 HUMAN HEALTH STREAMLINED RISK EVALUATION

The results of the human health SRE are summarized in Table G-1 for radionuclides and Table G-3 for non-radionuclides. Cancer is the major effect of concern from radionuclides. Radium is known to cause bone, head, and nasal passage tumors in humans; and radon, via inhalation exposure, causes lung cancer in humans. The potential excess lifetime cancer risk on human receptors from exposure to Ra-226 and other isotopes of the U-235 and U-238 decay chains in soil was assessed for the Sections 32 and 33 Mines Site. Non-cancer effects were also assessed for uranium as a metal. Radionuclides and other chemicals in the soil may be incidentally consumed by livestock, wildlife and humans. Persons traversing the Site may be exposed to contaminated dust by inhalation of particulate matter. Whole body (external) radiation may be experienced by nearby residents and trespassers on or near the Site itself. Key assumptions used in the human health risk evaluation are described below.

The Site mine surface expression was located in Section 32 along the border with Section 33 of



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T15N, R11W. Section 32 is part of the Navajo Nation (Casamero Lake Chapter). Section 33 is privately owned and is used for grazing cattle. Currently, several occupied residences are located the in Section 32, with the closest residence located approximately 2,000 feet west of the former mine surface expression. It is deemed likely that this residential area near the Site will continue and possibly expand in the future.

The risk from radon inhalation in an indoor atmosphere is outside the scope of this EECA; it will be addressed using the methodology outlined in the report *EPA Assessment of Risks from Radon in Homes* (EPA, 2003). An EPA review of outdoor radon data collected at uranium mine and mill sites (WESTON, 2012; Rio Algom Mining, 2016) approximately 12 miles east of the Sections 32 and 33 Mines Site, verified that clean-air dilution of radon emissions from those sites rapidly reduces the airborne concentrations to inconsequential levels (i.e., less than the EPA recommended limit for *indoor* concentrations of 4 pCi/L). While it is not accounted for in the risk calculations, the radon inhalation pathway *was* accounted for when providing a check of the site-specific action level via the Residual Radiation (RESRAD) modeling code (see discussion in EE/CA Section 2.2.1).

The risk to a resident from potential exposure to isotopes of the U-235 and U-238 decay chains was evaluated at the Sections 32 and 33 Mines Site. The EPA Preliminary Remediation Goal (PRG) calculator (https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg\_search) was used to calculate site-specific risk estimates for exposure from soil incidental ingestion, external exposure, and inhalation of particulates (details are included in Attachment 1). The risk estimates considered the isotopes of the U-235 decay chain (i.e., Th-231, Pa-231, Ac-227, Th-227, Fr-223, Ra-223, At-219, Rn-219, Bi-215, Po-215, Pb-211, Bi-211, Tl-207, Po-211, and stable Pb-207) and the U-238 decay chain (i.e., Th-234, Pa-234m, U-234, Pa-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, At-218, Bi-214, Rn-218, Po-214, Tl-210, Pb-210, Pb-210, Bi-210, Hg-206, Po-210, Tl-206 and stable Pb-206) as being in secular equilibrium. The assumption of secular equilibrium is that the parent is continually being renewed. The single isotopes of U-235 and U-238 were selected, and the calculator identified all the daughters in the chain. The risk estimates for each daughter are combined with the parent on a fractional basis. The fractional basis is determined by branching

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fractions where a progeny may decay into more than one isotope. The resulting risk estimate is now based on secular equilibrium of the full chain (EPA [2019b] PRG Calculator User's Guide (https://epa-prgs.ornl.gov/radionuclides/prg\_guide.html).

The PRG calculator was used to calculate residential PRGs for children and adults. Residential use assumes substantial soil exposure (especially for children) and long-term exposure. The residential receptor is assumed to spend most, if not all, of the day at home except for the hours spent at work. A resident may be exposed to radiological contaminants through incidental ingestion of soil, indoor and outdoor radon inhalation, and external exposure; however produce consumption was not assessed. It was assumed that due to the generally arid conditions of the site and observations of current residential activity, no home-grown produce will be consumed and thus contribute to radiation exposure. EPA derived PRG Calculator default values to represent reasonable maximum exposure to broad-based populations, typically 90-95 percentile values, which are well above the mean. The EPA default assumptions for the long-term resident are described below.

- An exposure duration of 26 years, with 6 years as a child and 20 years as an adult (EPA, 2014a).
- An exposure time of 24 hours per day (EPA, 2009).
- An annual exposure frequency of 350 days per year (EPA, 1991c).
- A soil ingestion rate of 100 mg/day for an adult and 200 mg/day for a child (EPA, 1991c).
- A value of 1.0 was used for the fraction ingested (FI), indicating that 100% of ingested soil is from the site.
- A body weight of 80 kg for adult and 15 kg for child (EPA, 2014a).
- Inhalation of chemicals adsorbed to respirable particles (particles less than or equal to 10 micrometers in diameter) was assessed using a default particulate emission factor (PEF) equal to 6.61E+09 cubic meters per kilogram. The default PEF was derived using default values adjusted to apply to the climate zone for Albuquerque, New Mexico and a 0.5-acre source size which is the standard residential lot size. The PEF equation relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The relationship is derived by Cowherd, et al. (Cowherd, 1985; as cited by EPA, 2019b) for a rapid assessment procedure



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applicable to a typical hazardous waste site, where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (i.e., years). This represents an annual average emission rate based on wind erosion that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures (EPA, 2019b).

Inadvertent ingestion of soil is common among children 6 years old and younger; therefore, the dose method used an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 26 years old. This health-protective approach was chosen to take into account the higher daily rates of soil ingestion in children, as well as the longer duration of exposure that is anticipated for a long-term resident (EPA, 2019a). Similar age-adjustments were performed for inhalation exposure route.

EPA manages risk to achieve 10<sup>-6</sup> to 10<sup>-4</sup> (1E-06 to 1E-04) overall excess cancer risks. EPA risk assessment guidance suggests that the average of the concentration is regarded as a reasonable estimate of the concentration likely to be contacted over time (EPA, 1989). Because of the uncertainty associated with any estimate of the representative average, the 95th percentile upper confidence limit (95UCL) on the arithmetic mean is generally used as the reasonable maximum exposure concentration (EPA, 1989) [Attachment 2]. Risk estimates were calculated using the reasonable maximum exposure point concentration (EPC). The EPC is based on the lower of the maximum detected and the 95% UCL on the mean. As shown in Table G-1, total cancer risks for the isotopes of the U-235 and U-238 decay chains (expressed as Ra-226 concentrations) for the Section 32 and 33 Mine Sites equaled or exceeded the 10<sup>-4</sup> (1E-04) overall cancer risk threshold. Section 32 total cancer risks in surface and subsurface soils were 2E-04 and 3E-04, respectively. Section 33 total cancer risks in surface and subsurface soils were 4E-03 and 4E-04, respectively. These results indicate the need for a response action to control releases and prevent radionuclide exposure. Note that these risk estimates also include contribution of the background level of Ra-226 (1.5 pCi/g). Note that the PRG Calculator default value for lifetime exposure for a residential land-use scenario, bulleted above and used in these calculations, is 26 years, including 6 years as a child and 20 years as an adult. The Navajo Nation government, however, leases Navajo allotment lands to eligible Navajo for residential purposes for 75 years. Substituting 75 years (6



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years as a child and 69 years as an adult) for lifetime residential exposure in the PRG Calculator would have the effect of increasing the total cancer risks in surface and subsurface soil approximately three-fold, exhibiting an even greater need for a response action to reduce the human health risk.

Uranium (as a metal) was the only non-radionuclide COPC. The USEPA RSL calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl\_search) was used to develop site-specific risk-based screening levels and to calculate non-cancer hazard quotients (HQs) for exposure from soil incidental ingestion and inhalation of particulates. Uranium is not considered to have carcinogenic effects; however, systemic, non-cancer effects are of concern. Dermal contact with uranium is not quantified because is not considered to be dermally absorbed through the skin and does not have an EPA-recommended dermal absorption factor.

The "Resident" land-use scenario template in the RSL Calculator was used to develop the risk estimates for the default resident (details are included in Attachment 1). The site-specific concentration is divided by its non-cancer-based screening level for residential soil to calculate a HQ. The individual HQs for each scenario (ingestion of soil and inhalation of particulates) for each COPC are summed to represent a total non-cancer hazard index (HI). A HI of one or less is generally considered "safe." A ratio greater than one suggests that, at a minimum, further evaluation (EPA, 2019a) is necessary.

As shown in Table G-3, the non-cancer hazard index for the most conservative resident (child) was 1 (when rounded to one significant figure) based on the single uranium detection. Based on the limited metals dataset, the potential for non-cancer health effects from uranium is not expected to be concern because the non-cancer hazard index for uranium does not exceed unity. It is anticipated that site actions to address radionuclide exposure by human receptors will be protective for exposure of human receptors to both radionuclides and non-radionuclide chemicals.

#### 5 ECOLOGICAL STREAMLINED RISK EVALUATION

The Sections 32 and 33 Mine Site are located in a remote area with the revegetated, previously disturbed mine area potentially providing habitat for ecological receptors. Wildlife inhabiting the



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Site may directly ingest radionuclides and chemicals, which may then be transported to organs or other sites within the wildlife receptors. Radionuclides and chemicals in the soil may be absorbed by plants consumed by wildlife. Radionuclides such as radium, radon, and daughter progeny may be inhaled, creating alpha-particle-emitting sources in the lungs of wildlife receptors. A screening level ecological risk assessment or SLERA (i.e., Steps 1 and 2 of EPA's 8-step ecological risk assessment process [EPA, 1997]) was performed as the ecological SRE to assess potential risk to ecological receptors from both radionuclide and non-radionuclide chemical contaminants. The results of the screening level ecological risk characterization are included in Table G-4 for radionuclides and Table G-5 for non-radionuclides. A refinement of conservative screening level assumptions (i.e., Step 3a of EPA's 8-step ecological risk assessment process [EPA, 2001]) was also performed to consider how the risk estimates would change if more realistic assumptions were used. The results of the refined ecological risk characterization are included in Table G-6.

#### 5.1 Ecological Risk-Based Screening Values

Literature-based ecological screening benchmark values for direct contact and food-chain evaluations are used to characterize potential ecological effects. The following sources were used to identify proposed ecological screening benchmark values for radionuclides and chemicals:

- EPA Ecological Soil Screening Levels (Eco-SSLs) (http://www.epa.gov/ecotox/ecossl)
- Los Alamos National Laboratory (LANL) ECORISK database, Release 4.1 (LANL, 2017).
- New Mexico Environment Department (NMED, 2017) Risk Assessment Guidance for Site Investigations and Remediation. Volume II -Soil Screening Guidance for Ecological Risk Assessments. March 2017. Tier 1 ecological screening levels (ESLs).
- Sheppard, Steve C., Marsha I. Sheppard, Marie-Odile Galler and Barb Sanipelli. 2005. Derivation of ecotoxicity thresholds for uranium, Journal of Environmental Radioactivity, Volume 79 (1), pages 55-83).

The Eco-SSLs include values for plant, soil invertebrate, bird, and mammal exposure to metals through direct contact and the food chain. Eco-SSLs are also available for protection of birds and mammals from the three primary feeding groups (herbivores, insectivores, and carnivores). The Eco-SSLs are based on no-effect toxicity values 1) to ensure risks are not underestimated, and 2) to provide a defensible conclusion that negligible ecological risk exist or that certain contaminants



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and exposure pathways can be eliminated from consideration (EPA, 1997). The Eco-SSLs are intended to be conservative screening values that can be used to eliminate contaminants clearly not associated with unacceptable risks (EPA, 2005a – 2005h, 2006, and 2007b – 2007e).

The LANL EcoRisk database includes ecological screening levels (ESLs) for avian, mammalian, earthworm, and plant exposure models for radionuclides and chemicals in soil. The ESLs for soildwelling invertebrates and terrestrial plants are based on direct contact with soil by plants and soil-dwelling organisms living in impacted soil. The ESLs for upper level wildlife are based on incidental ingestion of soil while feeding, preening, or nesting on the ground, and ingestion of food sources that have bio-accumulated contaminants. The wildlife functional feeding guilds for birds and mammals used to develop ESLs include herbivores, insectivores, and carnivores. The LANL EcoRisk database provides both no-effect and low-effect ESLs. The no-effect ESL is based on a no-observed-adverse-effect-level (NOAEL)-based toxicity reference value (TRV) that is protective of wildlife populations and sensitive individuals because it represents an exposure that is not associated with adverse impacts of low-level, long-term chemical effects (i.e., adverse effects on ability of individuals to develop into viable organisms, search for mates, breed successfully, and produce live and equally viable offspring). The NOAEL values are often extremely conservative and protective, and are designed to be an indication of no impacts if not exceeded (LANL, 2017). The low-effect ESL applies a lowest-observed-adverse-effect-levelbased TRV that is the lowest chronic effect level and is generally considered to be protective of wildlife populations.

The NMED has developed Tier 1 ESLs protective of plant community, deer mouse, horned lark, Kit fox (evaluated at sites greater than 267 acres), Pronghorn (evaluated at sites greater than 342 acres), and Red-tailed hawk (evaluated at sites greater than 177 acres). The key receptors selected as the representative species represent the primary producers as well as the three levels of consumer (primary, secondary, and tertiary) for the most common receptors found at hazardous waste sites in New Mexico. For plants, the Tier 1 screening level is based on an effect concentration for plant communities. For wildlife receptors, the Tier 1 screening level is based on NOAEL-based toxicity reference values (NMED, 2017).



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The EPA (2018) Region 4 has compiled soil ecological screening values for soil, surface water and sediment. Soil screening values that are intended to protect plants, soils invertebrates, avian wildlife or mammalian wildlife are reported from various sources. The Region 4 soil screening values typically address toxicity through direct exposure (e.g., toxicity to soil invertebrates such as earthworms and plants). For those chemicals that biomagnify, screening values may be back-calculated to derive screening values for avian or mammalian wildlife by considering trophic transfers from the abiotic medium to prey items.

The Sheppard et al (2005) study summarizes the literature available to set PNECs (predicted noeffect concentrations) for chemical toxicity of uranium to non-human biota. Values for terrestrial plants and other soil biota are used in this evaluation.

#### 5.2 Ecological Risk Estimates

Screening level risk characterization was performed using the hazard quotient (HQ) method to compare maximum surface (0-6 in bgs) and subsurface (12-18 in bgs) soil concentrations to Eco-SSLs and no-effect ESLs. An HQ of less than 1 indicates that the concentration is unlikely to cause adverse ecological effects. An HQ greater than 1 indicates that the potential for ecological risk is present and therefore the risk assessment process should continue. An HQ of 1 is the condition where the exposure and the dose associated with no adverse chronic effects are equal, indicating adverse effects at or below this soil concentration are unlikely (EPA, 2005a). The screening process considered the isotopes of the U-235 and U-238 decay chains, though ESLs were not available for all isotopes. The ecological SRE indicates potential for risk to ecological receptors from exposure to Ra-226, aluminum, barium, selenium, and vanadium (Table G-4 for radionuclides; Table G-5 for metals). Concentrations of aluminum, barium, and vanadium were below background levels (Table G-5); these three metals are not considered to be chemicals of potential ecological concern (COPEC). The maximum concentrations of Ra-226 exceeded receptor-specific ecological screening levels for soil invertebrates and birds (Appendix G, Table G-4); maximum concentration of selenium exceeded receptor-specific ecological screening levels for plants, soil invertebrates, birds and mammals (Appendix G, Table G-5).



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A SLERA uses conservative screening-level assumptions such as 100% site use, 100% bioavailability, 100% diet consists of the most contaminated dietary, and no-effect toxicity data to evaluate risk to populations of upper level organisms. Under more realistic site use conditions, the potential risk to individual organisms would be reduced. The average soil concentration and low effect ecological screening values were used to refine these risk estimates. In the refined ecological risk characterization (Table G-6), risks were calculated using a representative average exposure point concentration (i.e., 95% UCL on the mean). The average surface soil concentration of Ra-226 exceeds the low effect ESL for soil invertebrates (i.e., HQ>1), indicating potential risk to this receptor group. Selenium was detected in one of eight samples (12 mg/kg) and this concentration exceeds low-effect ESLs for plants, avian herbivores, insectivores and carnivores, and mammalian herbivores and insectivores (i.e., HQ>1).

The refined ecological risk evaluation indicates potential for risk to ecological receptors from exposure to Ra-226 (soil invertebrates only) and a single selenium detection (Table G-6).

The location where the detected selenium was measured is co-located with locations of elevated Ra-226; the sample was collected near the mine waste piles in Section 33. ESLs for radionuclides are higher (less stringent) than the proposed action level for protection of human health. Thus, it is anticipated that site actions to address radionuclide exposure by human receptors will be protective for exposure of ecological receptors to radionuclides. Selenium is a common metal in association with uranium in the Grants Mineral Belt deposits (Brookins, 1982). As an impurity, it may have been a waste metal in the uranium mine waste. Actions to address uranium are also expected to be protective of ecological receptors.

# 6 EVALUATION OF GRAZING OF FORAGE BY DOMESTICATED ANIMALS AND WILDLIFE

The results of the evaluation of the vegetative metals uptake samples are included in Table G-7. Surface vegetation samples were collected to determine the current vegetative nutrient values and uptake of potential hazardous constituents available to grazing animals (domesticated animals and wildlife). Tissue concentrations were compared to maximum tolerable limits (MTLs) developed by the National Research Council's Committee on Minerals and Toxic Substances in Diets and



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Water for Animals (NRC, 2005), which are defined as dietary level, that, when fed for a defined period of time, will not impair animal health or performance. Tissue concentrations are also compared to concentrations of trace elements in mature leaf tissue that are considered sufficient or normal and excessive or toxic (Kabata-Pendias and Pendias, 1992). With the exception of iron, nutrient (zinc, copper, and manganese) concentrations are less than MTLs for animals and within or less than sufficient/normal concentrations for plants (Table G-7). The iron concentration in four of eight samples exceed the MTLs for all listed mammals except swine. Iron is an essential nutrient; iron toxicity is dependent on absorption (NRC, 2005). Tissue samples for selenium and uranium (toxic metals) do not exceed thresholds. The vanadium concentrations do not exceed the MTLs for animals but two tissue of eight tissue samples fall within the excessive/toxic level for plants. Vanadium is commonly associated with uranium in the Grants Mineral Belt deposits (Brookins, 1982); concentrations measured in soil were less than regional background. The molybdenum concentration in one of eight samples exceeds the MTL for rodents, horse, cattle and sheep. Molybdenum toxicity is often associated with inadequate available copper; cattle show overt toxicosis when dietary molybdenum level is at 100 mg/kg or higher regardless of dietary copper or sulfur levels (NRC, 2005). No molybdenum concentrations in tissue exceed 100 mg/kg. The molybdenum concentration in one tissue sample falls between the range of sufficient/normal levels and excessive/toxic levels for plants.

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#### 7 Appendix G References

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#### Human Health and Ecological Streamlined Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

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#### Human Health and Ecological Streamlined Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

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Table G-1

Summary of Radionuclide Risk Estimates for the Residential Scenario - Streamlined Human Health Risk Evaluation

Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site

McKinley County, New Mexico

	9	Surface Soil		Subsurface Soil					
Resident Soil PRG	Secular Equilibrium for	Secular Equilibrium	Uranium	Secular Equilibrium	Secular Equilibrium	Uranium			
	U-235 <sup>#</sup>	for U-238*	TOTAL	for U-235 <sup>#</sup>	for U-238*	TOTAL			
Ingestion PRG	61	14.4	NA	61	14.4	NA			
Inhalation PRG	13100	28400	NA	13100	28400	NA			
External Exposure PRG	5.0	1.4	NA	5.0	1.4	NA			
Total PRG	4.59	1.3	NA	4.59	1.3	NA			
	95UCL	Radium-226 EP	С	95UCI	. Radium-226 E	PC			
Section 32 (pCi/g)	0.095	2.11	2.20	0.162	3.6	3.76			
	Res	ident Cancer Ri	sk <sup>a</sup>						
Ingestion	1.6E-07	1.5E-05	1.5E-05	2.7E-07	2.5E-05	2.5E-05			
Inhalation	7.2E-10	7.4E-09	8.2E-09	1.2E-09	1.3E-08	1.4E-08			
External Exposure	1.9E-06	1.6E-04	1.6E-04	3.3E-06	2.6E-04	2.7E-04			
TOTAL RISK	2E-06	2E-04	2E-04	4E-06	3E-04	3E-04			
	95UCL	Radium-226 EP	С	95UCI	. Radium-226 E	PC			
Section 33 (pCi/g)	1.94	43	45.03	0.21	4.60	4.81			
	Res	sident Cancer Ri	sk <sup>a</sup>						
Ingestion	3.2E-06	3.0E-04	3.0E-04	3.4E-07	3.2E-05	3.2E-05			
Inhalation	1.5E-08	1.5E-07	1.7E-07	1.6E-09	1.6E-08	1.8E-08			
External Exposure	3.9E-05	3.2E-03	3.2E-03	4.2E-06	3.4E-04	3.4E-04			
TOTAL RISK	4E-05	3E-03	4E-03	5E-06	4E-04	4E-04			

#### Notes:

# istope in U-235 decay chain; assume all isotopes in secular equilibrium (no decay); concentration based 0.045 times radium-226 concentration, where U-235 activity is approximately 2.2% of natural uranium (U-238, U-234, U-235) and assuming secular equilibrium and solving for U-235 (i.e., 0.022 x [U-238 + U-234 + U-235] = U-235) U total is simply referring to the concentrations of just U-235 in secular equilibrium plus U-238 in secular equilibrium (which includes U-234 in decay chain, whose concentration is typically included under the 'ordinary' definition of U total).

EPC exposure point concentration

HHRA human health risk assessment

pCi/g picocuries per gram

PRG preliminary remediation goal
UCL upper confidence limit



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<sup>&</sup>lt;sup>a</sup> Cancer risk calculated using the U.S. EPA's on-line PRG Calculator (https://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg\_search) to develop exposure-route PRG, which are based on a target cancer risk of 10<sup>-4</sup>. Output provided in Attachment 1. Concentrations also include background contribution (1.5 pCi/g Ra-226). Risk = (concentration / PRG) x 10<sup>-4</sup>.

<sup>\*</sup> assumes in secular equilibrium with radium-226 (no decay)

# Table G-2 Summary of Non-Radionuclide Analytical Results for the Residential Scenario - Streamlined Human Health Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Chemical name	Number detected^	Number analyzed^	Minimum concentration	Maximum concentration	Sample ID for maximum	EPA Residential November 2019 Residential Regional Screening Level <sup>a</sup>	NMED June 2019 Residential Soil Screening Level <sup>b</sup>	Mean Background <sup>c</sup>	COPC?
Non-Radionuclides									
Aluminum	8	8	8,300	25,000	32-02-31-181103-M & 33- 03-31-181103-M	7,700	7,800	54,423	No; ASL; BBC
Antimony	0	8	ND	ND		3.1	3.1	1.0	ND
Arsenic	7	8	2.5	6.5	33-05-31-181103-M	0.68	0.71	5.9	No; ASL; BBC#
Barium	8	8	41	250	32-03-32-181103-M	1,500	1,556	727	No; BSL
Beryllium	8	8	0.36	1.1	33-03-31-181103-M & 32- 02-31-181103-M	16	16	1.0	No; BSL
Cadmium	0	8	ND	ND		7.1	7.1	NA	ND
Calcium	8	8	2,800	22,000	32-01-31-181103-M		1.30E+07 (NUT)	35,809	No; BSL
Chromium	8	8	1.7	14	33-03-31-181103-M	12,000	9.7	55.5	No; BSL
Cobalt	8	8	1.8	8.6	33-05-31-181103-M	2.3	2.3	8.8	No; ASL; BBC
Copper	8	8	2.7	12	33-03-31-181103-M & 33- 04-31-181103-M	310	313	21	No; BSL
Iron	8	8	8,700	26000	33-03-31-181103-M & 33- 05-31-181103-M	5,500	5,475	20,898	No; ASL; BBC#
Lead	8	8	3.9	8.4	33-05-31-181103-M	400	400	18.1	No; BSL
Magnesium	8	8	2,100	5,200	33-03-31-181103-M		3.39E+05 (NUT)	7400 <sup>d</sup>	No; BBC
Manganese	8	8	76	240	32-03-31-181103-M & 32- 03-32-181103-M	180	1055	366.8	No; ASL; BBC
Mercury	0	8	ND	ND	-	1.1	2.3	0.046 d	ND
Nickel	8	8	2.7	14	33-03-31-181103-M, 33- 04-31-181103-M, & 33-05- 31-181103-M	150	156	27.9	No; BSL
Potassium	8	8	1,600	5,300	33-03-31-181103-M		1.56E+07 (NUT)	18000 <sup>d</sup>	No; BSL
Selenium	1	8	ND	12	33-01-31-181103-M	39	39	0.29	No; BSL
Silver	0	8	ND	ND		39	39	NA	ND
Sodium	0	8	ND	ND			7.82E+06 (NUT)	9700 <sup>d</sup>	ND
Thallium	0	8	ND	ND	-	0.078	0.078	9.1	ND
Uranium	1	8	ND	21	32-03-31-181103-M	1.6	23	2.5	Yes; ASL; IFD
Vanadium	8	8	15	37	33-03-31-181103-M	39	39	71.4	No; BSL
Zinc	8	8	11	66	33-05-31-181103-M	2,300	2346	44.3	No; BSL

All concentrations in mg/kg (ppm)

ASL - Above screening level

ABC - Above background concentration

BSL - Below screening level

BBC - Below background concentration

COPC - contaminant of potential concern

IFD - infrequently detected; see text

ND - not detected

NUT - essential nutrient; resident value from NMED, 2019

<sup>^</sup> includes field duplicates, maximum value taken from duplicate and normal sample



<sup>&</sup>lt;sup>a</sup> EPA Residential Regional Screening Level based on target risk of 10<sup>6</sup> and target hazard quotient of 0.1.

b NMED residential generic soil screening level based on target risk of 10<sup>5</sup> and target hazard quotient of 1, adjusted by a factor of 10 to account for additive risk.

<sup>&</sup>lt;sup>c</sup> Average concentration, New Mexico, Background Soil Concentration Database, EcoSSL Attachment 1-4, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Review of Background Concentrations for Metals, OSWER Directive 92857-55, Revised July 2007. https://www.epa.gov/sites/production/files/2015-09/documents/ecossl\_attachment\_1-4.pdf. Average for cadmium is value for "not specified".

d Mean for Western US (Shacklette, H.T. and J.G. Boernren. 1984. Element Concentrations in Soil and Other Surface Materials of the Counterminous United States. USGS Professional Paper 1270)

<sup>#</sup> maximum concentration is less than 2 times the mean background

Table G-3
Summary of Non-Radionuclide Cancer Risk and Noncancer Hazard Index for the Residential Scenario - Streamlined Human Health Risk Evaluation Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

	Maximum	Age-Adjusted	Resid	ent HI	
Non-radionuclide COPC	(mg/kg)	Resident Cancer Risk	Child	Adult	Target Organ Endpoint
Section 32					
Uranium	21	Not a Carcinogen	1	0.1	Kidney/Urinary System
Section 33					
No COPCs					

Resident Hazard Index was calculated from EPA RSL calculator (Attachment 1)

Maximum detected concentration was used as a "worst-case" scenario.

COPC contaminant of potential concern

HHRA human health risk assessment

HI hazard index



#### Table G-4

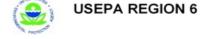
#### Screening Level Ecological Risk Characterization For Surface and Subsurface Soil - Radionuclides Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines **McKinley County, New Mexico**

			f Detected										ground	T		I			an ground	Mamr	
	Frequency of	Minimum	trations* Maximum	Location of Maximum		Pla	ant	Soil inve	rtebrates	Avian he	erbivore	insec	tivore	Avian c	arnivore	Mammalia	n herbivore	insec	tivore	carn	ivore
COPEC	Detection#	(mg/kg)	(mg/kg)	Concentration	Background <sup>a</sup>	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)	EcoSSL <sup>b</sup>	HQ (max)
					Sur	rface Soil (0	-6 in bgs)									,	Surface Soil	(0-6 in bgs	:)		
Uranium 238 Decay C	hain Isotopes	_	52.7		-	400	0.4	1100	0.0	3300	0.0	4000	0.0	4200	0.0	2000	0.0	2100	0.0	2100	0.0
U-236 Th-234**			52.7			NSL	0.1	NSL	0.0	NSL		NSL		NSL		NSL	0.0	NSL		NSL	
Pa-234m**		-	52.7	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Pa-234**		-	52.7	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
U-234**		-	52.7		-	440	0.1	2200	0.0	14000	0.0	69000	0.0	260000	0.0	36000	0.0	140000	0.0	110000	0.0
Th-230**		-	52.7	-	-	200	0.3	52	1	1200	0.0	2200	0.0	17000	0.0	9900	0.0	81000	0.0	68000	0.0
Radium 226 (pCi/g)*	9/9	1.53	52.7	33-26-31-180807	1.5	54	0.98	1.5	40	34	2	8.2	10	61	0.9	340	0.2	510	0.1	370	0.1
Rn-222** Po-218**		-	52.7 52.7			NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	-	NSL NSL	
Pb-214**			52.7			NSL		NSL	-	NSL		NSL	-	NSL		NSL		NSL	-	NSL	
At-218**		-	52.7		-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Bi-214**		-	52.7		-	NSL		NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	
Rn-218**	-	1	52.7	-	-	NSL	-	NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	
Po-214**		-	52.7	-		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
TI-210**		-	52.7			NSL 2400		NSL 1200		NSL		NSL		NSL		NSL 4400		NSL 4500		NSL 4400	
Pb-210** Bi-210**		-	52.7 52.7			3400 NSL	0.0	1200 NSL	0.0	6000 NSL	0.0	6200 NSL	0.0	8500 NSL	0.0	4400 NSL	0.0	4500 NSL	0.0	4400 NSL	0.0
Po-210**	-	-	52.7	-	-	NSL		NSL		NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Uranium 235 Decay C	hain Isotopes					•															
Uranium-235 <sup>&amp;</sup>	-	-	2.4		0.068	440	0.0	1600	0.0	6300	0.0	9500	0.0	10000	0.0	4700	0.0	5200	0.0	5200	0.0
Th-231	-	-	2.4	-	-	NSL	-	NSL	-	NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	-
Pa-231		-	2.4			NSL		NSL	-	NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Ac-227 Th-227		-	2.4			NSL NSL		NSL NSL		NSL NSL		NSL NSL	-	NSL NSL		NSL NSL		NSL NSL	-	NSL NSL	
Fr-223			2.4			NSL		NSL		NSL		NSL	-	NSL		NSL		NSL	_	NSL	
Ra-223		-	2.4		-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
At-219		-	2.4		•	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Rn-219	-	1	2.4	-	-	NSL	-	NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	
Bi-215		-	2.4	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Po-215 Pb-211		-	2.4		-	NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	-	NSL NSL	
Bi-211		-	2.4			NSL	-	NSL		NSL		NSL	_	NSL		NSL		NSL	_	NSL	
TI-207		-	2.4	-	-	NSL	-	NSL		NSL		NSL	_	NSL		NSL	_	NSL	_	NSL	
Po-211		-	2.4	-		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
					Subsu	rface Soil (	12-18 in bg:	s)								Sub	surface Soi	l (12-18 in £	bgs)		
Uranium 238 Decay C	hain Isotopes					1	1				1		1				•		1	•	1
U-238**		-	4.6		-	400	0.0	1100	0.0	3300	0.0	4000	0.0	4200	0.0	2000	0.0	2100	0.0	2100	0.0
Th-234** Pa-234m**		-	4.6 4.6			NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	
Pa-234**		-	4.6	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
U-234**		-	4.6			440	0.0	2200	0.0	14000	0.0	69000	0.0	260000	0.0	36000	0.0	140000	0.0	110000	0.0
Th-230**		-	4.6		-	200	0.0	52	0.1	1200	0.0	2200	0.0	17000	0.0	9900	0.0	81000	0.0	68000	0.0
Radium 226 (pCi/g)*	9/9	2.6	4.6	33-24-2-31-180807	1.5	54	0.1	1.5	3	34	0.1	8.2	0.0	61	0.1	340	0.0	510	0.0	370	0.0
Rn-222**		-	4.6			NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Po-218**		-	4.6	-	-	NSL		NSL		NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Pb-214** At-218**			4.6 4.6		-	NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	
Bi-214**	-	-	4.6	-		NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	-	NSL	
Rn-218**		-	4.6	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Po-214**		-	4.6			NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
TI-210**		-	4.6	-	-	NSL		NSL		NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Pb-210**		-	4.6		-	3400	0.0	1200	0.0	6000	0.0	6200	0.0	8500	0.0	4400	0.0	4500	0.0	4400	0.0
Bi-210** Po-210**		-	4.6 4.6		-	NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	
Uranium 235 Decay C		-	7.0			ITOL		INOL		INOL		HOL		1101		1401		INOL		HOL	
Uranium-235 <sup>a</sup>		-	0.21		0.068	440	0.0	1600	0.0	6300	0.0	9500	0.0	10000	0.0	4700	0.0	5200	0.0	5200	0.0
Th-231	-	-	0.21		-	NSL	-	NSL	-	NSL	-	NSL	-	NSL	-	NSL	-	NSL	-	NSL	-
Pa-231	-	-	0.21	-	1	NSL	-	NSL	-	NSL	-	NSL	-	NSL		NSL	-	NSL	-	NSL	-
Ac-227			0.21			NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Th-227 Fr-223		-	0.21 0.21		-	NSL NSL		NSL NSL		NSL NSL	-	NSL NSL		NSL NSL		NSL NSL		NSL NSL	-	NSL NSL	
Fr-223 Ra-223			0.21			NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	-	NSL	
At-219	-	-	0.21	-	-	NSL		NSL		NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Rn-219		-	0.21			NSL		NSL		NSL		NSL	-	NSL		NSL	-	NSL	-	NSL	
Bi-215	-	-	0.21		-	NSL		NSL		NSL		NSL		NSL		NSL		NSL	-	NSL	-
Po-215	-	-	0.21	-	-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	-
Pb-211	-	-	0.21			NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Bi-211		-	0.21		-	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
TI-207 Po-211		-	0.21 0.21	-	-	NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL		NSL NSL	
1 0-211			U.Z I			INOL		INOL		INOL		INOL		INOL		INOL		INOL		INOL	

Bold values indicate concentrations that exceed ecological screening level or background; bold and shading indicates HQ exceeds unity (based on one significant figure).

\*\* isotope in U-238 decay chain; assumes in secular equilibrium with radium-226

& assumed all isotopes in U-235 decay chain in secular equilibrium; U-235 decay chain concentrations calculated to be 0.045 times radium-226 concentration, where U-235 activity is assumed to be approximately 2.2% of natural uranium (U-238, U-234, U-235), (i.e., 0.022 x [U-238 + U-234 + U-235]= U-235) U total is simply referring to the concentrations of just U-235 in secular equilibrium plus U-238 in secular equilibrium (which includes U-234 in decay chain, whose concentration is typically included under the 'ordinary' definition of U total).



<sup>#</sup> includes duplicate sample

<sup>\*</sup> dataset includes minimum/maximimum of MCA and offsite laboratory results

COPEC = chemical of potential environmental concern HQ = Hazard quotient = maximum concentration / screening level

max= maximum concentration

NSL - no screening level

<sup>&</sup>lt;sup>a</sup> Background threshold value for radium-226 as reported in the Section 32/33 Mines Removal Site Evaluation Report (Weston, September 2019).

b LANL ESL Version 4.1; values for avian herbivore (American robin), avian insectivore (American robin), and avian intermediate carnivore (American kestrel); mammalian herbivore (desert cottontail); mammalian insectivore (montane shrew) and mammalian top carnivore (red fox).

#### Table G-5

# Screening Level Ecological Risk Characterization For Surface and Subsurface Soil - Metals Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

														,	,,																		
			of Detected entrations*				Pl	ant		Soil inve	rtebrates	Avian h	erbivore		ground tivore	Omnivore La	e (Horned rk)	Avian c	arnivore		ore (Red-tailed 177 acres)	Mammalia	an herbivore		ian ground ctivore	-	ore (Deer ouse)		malian nivore		ore (Kit fox; acres)	Herbivore ( antelope;	
COPEC	Frequency of Detection#	Minimun (mg/kg)		Location of Maximum Concentration	Background <sup>a</sup>	EcoSSL°	HQ (max)	NMED Tier 1 ESL <sup>d</sup>	HQ (max)	EcoSSL°	HQ (max)	EcoSSL°	HQ (max)	EcoSSL°	HQ (max)	NMED Tier 1 ESL <sup>d</sup>	HQ (max)	EcoSSL°	HQ (max	NMED Tier 1	HQ (max)	EcoSSL°	HQ (max)	EcoSSL°	HQ (max	NMED Tier 1	HQ (max)	EcoSSL°	HQ (max)	NMED Tier 1 ESL <sup>d</sup>		NMED Tier 1	1 HQ (max
	,			Non-Radionuclides				•			1		1						1			1							1				
Aluminum*	8/8	8,300	25,000	32-02-31-181103-M & 33-03- 31-181103-M	54,423	NSL		NSL		NSL	_	NSL	_	NSL		520	48	NSL		4000	6.3	NSL		NSL		564	44	NSL	_	2500	10	NSL	
Antimony <sup>\$</sup>	0/8	ND	ND		1.0	11		11.4		78		NSL		NSL		NSL		NSL	-	NSL		10		0.27		0.536		4.9		2.380		NSL	
Arsenic <sup>\$</sup>	7/8	2.5	6.5	33-05-31-181103-M	5.9	18	0.4	18	0.4	6.8	1	67	0.1	43	0.2	10.6	0.6	1100	0.01	81.5	0.1	170	0.04	46	0.1	9.5	0.7	170	0.04	42.0	0.2	36.1	0.2
Barium <sup>\$</sup>	8/8	41	250	32-03-32-181103-M	727	110	2	118	2	330	0.8	720	0.3	820	0.3	348	0.7	7500	0.03	2680	0.1	3200	0.1	2000	0.1	471	0.5	9100	0.03	2090	0.1	NSL	
Beryllium <sup>\$</sup>	8/8	0.36	1.1	33-03-31-181103-M & 32-02- 31-181103-M	1.0	2.5	0.4	2.5	0.4	40	0.03	NSL		NSL		NSL	-	NSL		NSL		21	0.05	34	0.03	4.8	0.2	90	0.01	21.5	0.05	NSL	
Cadmium	0/8	ND	ND		NA	32		32		140	-	28		0.77		7.0		630	-	53.5		73		0.36		7.0		84		31.1	-	NSL	
Calcium	8/8	2,800	22,000	32-01-31-181103-M	35,809	NUT		NUT		NUT	-	NUT		NUT		NUT		NUT	-	NUT		NUT		NUT		NUT		NUT		NUT	-	NUT	
Chromium <sup>\$</sup>	8/8	1.7	14	33-03-31-181103-M	55.5	NSL		NSL	-	NSL	-	78	0.2	23	0.6	12.6	1	780	0.02	96.8	0.1	380	0.04	34	0.4	21.8	0.6	180	0.08	97.0	0.1	NSL	T-
Cobalt	8/8	1.8	8.6	33-05-31-181103-M	8.8	13	0.7	13	0.7	NSL	-	270	0.03	120	0.07	36.0	0.2	1300	0.007	277	0.03	2100	0.004	230	0.04	66.6	0.1	470	0.02	296	0.03	58	0.1
Copper	8/8	2.7	12	33-03-31-181103-M & 33-04- 31-181103-M	21	70	0.2	70	0.2	80	0.2	76	0.2	28	0.4	19.2	0.6	1600	0.01	147	0.1	1100	0.01	49	0.2	50.9	0.2	560	0.02	226	0.05	NSL	
Iron	8/8	8.700	26000	33-03-31-181103-M & 33-05- 31-181103-M	20.898	NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL		NSL	
Lead	8/8	3.9	8.4	33-05-31-181103-M	18.1	120	0.1	120	0.1	1700	0.005	46	0.2	11	0.8	7.7	1	510	0.02	59.3	0.1	1200	0.01	56	0.2	42.7	0.2	460	0.02	190	0.04	173	0.05
Magnesium	8/8	2,100	5,200	33-03-31-181103-M	7,400	NUT		NUT	-	NUT	-	NUT	-	NUT	-	NUT		NUT	-	NUT		NUT	-	NUT	-	NUT		NUT	-	NUT	-	NUT	
Manganese	8/8	76	240	32-03-31-181103-M & 32-03- 32-181103-M	367	220	1	220	1	450	0.5	4300	0.1	4300	0.1	847	0.3	65000	0.004	6520	0.04	5300	0.05	4000	0.06	468	0.5	6200	0.04	2080	0.1	5770	0.04
Mercury <sup>s,</sup>	0/8	ND	ND		0.046	0.3		34.9		0.05	-	0.067		0.013		0.1		0.058	-	0.692		23		1.7		12.8		76		57.0		NSL	
Nickel	8/8	2.7	14	33-03-31-181103-M, 33-04-31 181103-M, & 33-05-31- 181103-M	27.9	38	0.4	38	0.4	280	0.05	210	0.07	NSL		31.7	0.4	2800	0.005	244	0.06	340	0.04	NSL		15.5	0.9	130	0.1	68.7	0.2	289	0.05
Potassium	8/8	1,600	5,300	33-03-31-181103-M	18,000 i	b NUT	0.4	NUT	0.4	NUT	0.05	NUT	0.07	NUT	<del></del>	NUT		NUT	0.005	NUT	0.06	NUT	0.04	NUT	+	NUT	0.8	NUT	0.1	NUT	10.2	NUT	0.05
Selenium	1/8	1,000	12	33-01-31-181103-M	0.29	0.52	23	0.52	23	4.1	3	2.2	5	1.2	10	1.37	9	83	0.1	10.6	1	2.7	4	0.63	19	1.3	9	2.8	4	5.78	2	NSL	<del></del>
Silver	0/8	ND	ND		NA	560		560		NSL		69		4.2		10.4		930		73.5	<del></del>	1500		14		54.7		990		243	-	2.9	+
Sodium	0/8	ND	ND ND		9.700	NUT	-	NUT	_	NUT	-	NUT	<del>-</del>	NUT	_	NUT		NUT	-	NUT		NUT	-	NUT	<u> </u>	NUT	<b>—</b>	NUT		NUT	+	NUT	<del>  -</del>
Thallium <sup>\$</sup>	0/8	ND	ND		9.1	0.05		0.05		NSL		6.9		4.5		1.66		48		12.7		1.2		0.42		0.065		5		0.29	-	NSL	<b>†</b>
Uranium <sup>@</sup>	1/8	21	21	32-03-31-181103-M	2.5	250	0.08	NSL		100	0.2	1500	0.01	1100	0.02	NSL		14000	0.002	NSL		1000	0.02	480	0.04	NSL		4800	0.004	NSL	-	NSL	-
Vanadium <sup>\$</sup>	8/8	15	37	33-03-31-181103-M	71.4	60	0.6	60	0.6	NSL	-	13	3	7.8	5	1.6	23	140	0.3	12.5	3	1300	0.03	280	0.1	37.8	1	580	0.1	168.0	0.2	289	0.1
Zinc	8/8	11	66	33-05-31-181103-M	44.3	160	0.4	160	0.4	120	0.6	950	0.07	46	1	313	0.2	30000	0.002	2410	0.03	6800	0.010	79	0.8	685	0.1	10000	0.007	3050	0.02	2890	0.02

Bold values indicate concentrations that exceed ecological screening level; bold and shading indicates HQ exceeds unity (based on one significant figure). Thick border around HQ>1 indicates maximum concentration also exceeds background

COPEC = chemical of potential environmental concern

HQ = Hazard quotient = maximum concentration / screening level

max= maximum concentration
NSL - no screening level

<sup>a</sup> Average concentration, New Mexico, Background Soil Concentration Database, EcoSSL Attachment 1-4, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Review of Background Concentrations for Metals, OSWER Directive 92857-55, Revised July 2007. https://www.epa.gov/sites/production/files/2015-09/documents/ecossl\_attachment\_1-4.pdf. Average for cadmium is value for "not specified".

<sup>b</sup> Mean for Western US (Shacklette, H.T. and J.G. Boernren. 1984. Element Concentrations in Soil and Other Surface Materials of the Counterminous United States. USGS Professional Paper 1270)

Weat in Vesterin Question (Search (1994) and Control (1994) (1994

d NMED (2017). Risk Assessment Guidance for Site Investigations and Remediation. Volume II -Soil Screening Guidance for Ecological Risk Assessments. March 2017. Tier 1 ecological screening level (ESL).

\* NMED ESLs are pH dependent; aluminum is identified as a COPC only at sites where the soil pH is less than 5.5 (U.S. EPA. Ecological Soil Screening Level for Aluminum, Interim Final. OSWER Directive 9285.7-6. November 2003).



#### Table G-6

#### Refined Ecological Risk Characterization For Surface and Subsurface Soil Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

			PI	ant	Soil invert	tebrates	Avian h	erbivore		ground tivore	Avian c	arnivore		malian oivore		an ground		malian nivore
COPEC	EPC (mg/kg)*	Background <sup>a,b</sup>	Low Effect ESL <sup>d</sup>	Low Effect HQ	Low Effect ESL <sup>d</sup>	Low Effect HQ	Low Effect ESL <sup>d</sup>	Low Effect HQ										
Selenium	12	0.29	3	4	41	0.3	1.9	6	1.4	9	7.5	2	3.4	4	1	12	130	0.1
Surface Soil (0-6 in bg	ıs)																	
Radium 226 (pCi/g)*	24	1.5	540	0.0	15	2	340	0.1	82	0.3	610	0.0	3400	0.01	5100	0.00	3700	0.01
Subsurface Soil (12-18	8 in bgs)															•		
Radium 226 (pCi/g)*	3.9	1.5	540	0.01	15	0.3	340	0.01	82	0.0	610	0.01	3400	0.001	5100	0.001	3700	0.001

Bold values indicate concentrations that exceed ecological screening level; bold and shading indicates HQ exceeds unity (based on one significant figure). Thick border around HQ>1 indicates maximum concentration also exceeds background.

COPEC = chemical of potential environmental concern

HQ = Hazard quotient = maximum concentration / screening level

<sup>&</sup>lt;sup>a</sup> Background threshold value for radium-226 as reported in the Section 32/33 Mines Removal Site Evaluation Report (Weston, September 2019).

b Average concentration, New Mexico, Background Soil Concentration Database, EcoSSL Attachment 1-4, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs), Review of Background Concentrations for Metals, OSWER Directive 92857-55, Revised July 2007. https://www.epa.gov/sites/production/files/2015-09/documents/ecossl\_attachment\_1-4.pdf.

<sup>&</sup>lt;sup>c</sup> Mean for Western US (Shacklette, H.T. and J.G. Boernren. 1984. Element Concentrations in Soil and Other Surface Materials of the Counterminous United States. USGS Professional Paper 1270)

d LANL low effect ESL Version 4.1; values for avian herbivore (American robin), avian insectivore (American robin), and avian intermediate carnivore (American kestrel); mammalian herbivore (desert cottontail); mammalian insectivore (montane shrew) and mammalian top carnivore (red fox)

<sup>\*</sup> Exposure Point Concentration (EPC) is 95% UCL for Radium 226. Selenium EPC is based on one detection.

# Table G-7 Comparison of Plant Tissue Concentrations to Maximum Tolerable Limits for Animals and Normal/Toxic Limits for Plants Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Plant Analysis	Transect Community Type *	Iron	Zinc	Copper	Manganese	Molybdenum	Uranium	Vanadium	Selenium
Sample I.D.		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
32/33-P01-181127	Coniferous Woodland (One-seed Juniper/Pinyon Pine/Bigelow Sage)	1,082	20	4.0	43	1.0	<0.10	0.6	0.1
32/33-P02-181127	Great Basin Desert Scrub –(Four-wing	2,288	34	5.7	48	8.6	2.3	6.9	0.7
32/33-P03-181127	saltbush/Blue Grama/Galleta/W. Wheat Grass)	260	22	4.0	55	0.9	10.7	1.6	0.8
32/33-P04-181127	windat Grass)	2,471	28	5.9	109	1.2	7.6	6.9	<0.10
32/33-P05-181128	Great Basin Desert Scrub – (Four-wing Saltbush/Kochia/Gumweed/Various Weeds)	283	20	4.0	21	0.5	<0.10	1.6	0.8
32/33-P06-181128	Arroyo Riparian (Rabbitbrush/Saltbush/Galleta)	253	24	6.1	40	0.5	<0.10	0.3	1.9
32/33-P07-181128	Great Basin Desert Scrub – (Four-wing Saltbush/Kochia/Gumweed/Various Weeds)	192	24	4.0	21	0.5	0.9	0.1	<0.10
32/33-P08-181128	Arroyo Riparian (Rabbitbrush/Saltbush/Galleta)	608	21	4.0	29	0.5	<0.10	1.8	<0.10
Maximum Tolerable L	imits (MTL) of Minerals in the Feed (mg/	kg dry matt	er) <sup>a</sup>		•	<u>'</u>		<b>"</b>	
Rodents		500	500	500	2000	7	100 - 400**	NA	5
Poultry		500	500	250	2000	100	NA	25 (<5 laying hens)	3
Swine		3000	1000	250	1000	150	NA	10	4
Horse		500	500	250	400	5*	NA	10	5
Cattle		500	500	40	2000	5*	NA	50	5
Sheep		500	300	15	2000	5*	NA	50	5
Trace Elements in Ma	ture Leaf Tissue*** (ppm dry weight) b				•			•	
Sufficient/Normal	11.1 3 7	NA	27 - 150	5 - 30	30 - 300	0.2 - 5	NA	0.2 - 1.5	0.01 - 2
Toxic/Excessive		NA	100 - 400	20 - 100	400 - 1000	10 - 50	NA	5 - 10	5 - 30

Bold indicates concentration exceeds lowest MTL for animals and shading indicates concentration within toxic/excessive range for plants.

<sup>\*</sup> NNV5. 2019a. Natural Resources Evaluation, Tronox NAUM, Section 32 and 36, McKinley County, New Mexico. Prepared for US Environmental Protection Agency Region 6 and Weston Solutions, Inc. June.



<sup>\*</sup> toxicosis caused by <25 mg/kg is often associated with inadequate available copper; cattle show overt toxicosis when dietary molybdenum level is at 100 mg/kg or higher regardless of dietary copper or sulfur levels (NRC, 2005).

<sup>\*\*</sup>Maximum tolerable intake for domestic animals is probably between 100 and 400 mg/kg diet (NRC, 2005).

<sup>\*\*\*</sup> Values are not given for very sensitive or highly tolerant plant species (Kabata-Pendias and Pendias, 1992).

<sup>&</sup>lt;sup>a</sup> defined as dietary level, that, when fed for a defined period of time, will not impair animal health or performance (NRC, 2005). ppm = parts per million = millgrams per kilogram (mg/kg)

<sup>&</sup>lt;sup>a</sup> National Research Council (NRC). 2005. Mineral Tolerance of Animal. 2nd Revised Edition. The National Academies Press. Washington, D.C.

<sup>&</sup>lt;sup>b</sup> Kabata-Pendias, Alina and Henryk Pendias. 1992. Trace Elements in Soils and Plants. 2nd Edition. CRC Press. Boca Raton, FL.

# ATTACHMENT 1 PRG CALCULATOR INPUT AND OUTPUT AND RSL CALCULATOR INPUT AND OUTPUT

# Site-specific Resident Equation Inputs for Soil (PRG Calculator) \* Input values different from Resident defaults are highlighted.

Variable	Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
City (Climate Zone)	Default	Albuquerque, NM (3)
Climate zone	Temperate	Temperate
C (PEF Dispersion Constant)	216.108	205.1782
Cover thickness for GSF <sub>o</sub> (gamma shielding factor) cm	0 cm	0 cm
Cover thickness for GSF <sub>b</sub> (gamma shielding factor) cm	0 cm	0 cm
ED <sub>res-a</sub> (exposure duration - resident adult) y	20	20
ED <sub>res-c</sub> (exposure duration - resident child) y	6	6
EF <sub>res-a</sub> (exposure frequency - resident adult) day/y	350	350
EF <sub>res-c</sub> (exposure frequency - resident child) day/y	350	350
TR (target cancer risk) unitless	0.000001	0.0001
$F(x)$ (function dependent on $L_m/U_t$ ) unitless	0.194	0.0553
PEF (particulate emission factor) m³/kg	1.36E+09	6.61E+09
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	81.84858573
A <sub>s</sub> (acres)	0.5	0.5
Site area for ACF (area correction factor) m <sup>2</sup>	1000029 m <sup>2</sup>	1000029 m <sup>2</sup>
ED <sub>res</sub> (exposure duration - resident) y	26	26
ED <sub>res-a</sub> (exposure duration - resident adult) y	20	20
ED <sub>res-c</sub> (exposure duration - resident child) y	6	6
EF <sub>res</sub> (exposure frequency - resident) day/y	350	350
EF <sub>res-a</sub> (exposure frequency - resident adult) day/y	350	350
EF <sub>res-c</sub> (exposure frequency - resident child) day/y	350	350
ET <sub>res</sub> (exposure time - resident) hr/day	24	24
ET <sub>res-a</sub> (exposure time - resident adult) hr/da	24	24
ET <sub>res-c</sub> (exposure time - resident child) hr/da	24	24
ET <sub>res-i</sub> (exposure time - indoor resident) hr/da	16.416	16.416
ET <sub>res-o</sub> (exposure time - outdoor resident) hr/da	1.752	1.752
GSF <sub>i</sub> (gamma shielding factor - indoor) unitles	0.4	0.4
IFA <sub>res-adj</sub> (age-adjusted soil inhalation factor - resident) r <sup>3</sup>	161000	161000
IFS <sub>res-adj</sub> (age-adjusted soil ingestion factor - resident) m	1120000	1120000
IRA <sub>res-a</sub> (inhalation rate - resident adult) n³/day	20	20
IRA <sub>res-c</sub> (inhalation rate - resident child) n³/day	10	10
IRS <sub>res-a</sub> (soil intake rate - resident adult) mg/da	100	100
IRS <sub>res-c</sub> (soil intake rate - resident child) mg/da	200	200
t <sub>res</sub> (time - resident) yı	26	26
TR (target cancer risk) unitless	0.000001	0.0001
Soil type	Default	Default
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.02
U <sub>t</sub> (equivalent threshold value	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

### Site-specific Resident PRGs for Soil (PRG Calculator)

	Ingestion PRG TR=0.0001	Inhalation PRG TR=0.0001	External Exposure PRG TR=0.0001	Produce Consumption PRG TR=0.0001	Total PRG TR=0.0001
Isotope	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Secular Equilibrium PRG for U-235	6.08E+01	1.31E+04	4.96E+00	-	4.59E+00
Secular Equilibrium PRG for U-238	1.44E+01	2.84E+04	1.36E+00	-	1.25E+00

### Site-specific Resident Equation Inputs for Soil (RSL Calculator) \* Input values different from Resident defaults are highlighted

Variable	Kesident Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
A (VF Dispersion Constant)	11.911	11.911
A (VF Dispersion Constant)  A (VF Dispersion Constant - Mass Limit)	11.911	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
B (VF Dispersion Constant)	18.4385	18.4385
B (VF Dispersion Constant)  B (VF Dispersion Constant - Mass Limit)	18.4385	17.9869
City (PEF Climate Zone) Selection	Default	Albuquerque, NM
City (VF Climate Zone) Selection	Default	Default
C (PEF Dispersion Constant)	216.108	205.1782
C (VF Dispersion Constant)	209.7845	209.7845
C (VF Dispersion Constant) C (VF Dispersion Constant - Mass Limit)	209.7845	205.1782
foc (fraction organic carbon in soil) g/g	0.006	0.006
$F(x)$ (function dependent on $U_m/U_t$ ) unitless	0.194	0.0553
n (total soil porosity) L <sub>pore</sub> /L <sub>soil</sub>	0.43396	0.43396
p <sub>b</sub> (dry soil bulk density) g/cm³	1.5	1.5
p <sub>b</sub> (dry soil bulk density - mass limit) g/cm <sup>3</sup>	1.5	1.5 6609630250
PEF (particulate emission factor) m³/kg		
p <sub>s</sub> (soil particle density) g/cm <sup>3</sup>	2.65	2.65
$Q/C_{wind}$ (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	81.84858573
Q/C <sub>vol</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	68.18	68.18
Q/C <sub>vol</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	68.18	81.84858573
A <sub>s</sub> (PEF acres)	0.5	0.5
A <sub>s</sub> (VF acres)	0.5	0.5
A <sub>s</sub> (VF mass-limit acres)	0.5	0.5
AF <sub>0-2</sub> (mutagenic skin adherence factor) mg/cm <sup>2</sup>	0.2	0.2
AF <sub>2-6</sub> (mutagenic skin adherence factor) mg/cm <sup>2</sup>	0.2	0.2
AF <sub>6-16</sub> (mutagenic skin adherence factor) mg/cm <sup>2</sup>	0.07	0.07
AF <sub>16-26</sub> (mutagenic skin adherence factor) mg/cm <sup>2</sup>	0.07	0.07
AF <sub>res-a</sub> (skin adherence factor - adult) mg/cm <sup>2</sup>	0.07	0.07
AF <sub>res-c</sub> (skin adherence factor - child) mg/cm <sup>2</sup>	0.2	0.2
AT <sub>res</sub> (averaging time - resident carcinogenic)	365	365
BW <sub>0-2</sub> (mutagenic body weight) kg	15	15
BW <sub>2-6</sub> (mutagenic body weight) kg	15	15
BW <sub>6-16</sub> (mutagenic body weight) kg	80	80
BW <sub>16-26</sub> (mutagenic body weight) kg	80	80
BW <sub>res-a</sub> (body weight - adult) kg	80	80
BW <sub>res-c</sub> (body weight - child) kg	15	15
DFS <sub>res-adj</sub> (age-adjusted soil dermal factor) mg/kg	103390	103390
DFSM <sub>res-adj</sub> (mutagenic age-adjusted soil dermal factor) mg/kg	428260	428260
ED <sub>res</sub> (exposure duration) years	26	26
ED <sub>0-2</sub> (mutagenic exposure duration) years	2	2
ED <sub>2-6</sub> (mutagenic exposure duration) years	4	4
ED <sub>6-16</sub> (mutagenic exposure duration) years	10	10
ED <sub>16-26</sub> (mutagenic exposure duration) years	10	10
ED <sub>res-a</sub> (exposure duration - adult) years	20	20
ED <sub>res-c</sub> (exposure duration - child) years	6	6
EF <sub>res</sub> (exposure frequency) days/year	350	350
EF <sub>0-2</sub> (mutagenic exposure frequency) days/year	350	350
EF <sub>2-6</sub> (mutagenic exposure frequency) days/year	350	350
EF <sub>6-16</sub> (mutagenic exposure frequency) days/year	350	350
EF <sub>6-16</sub> (mutagenic exposure frequency) days/year  EF <sub>16-26</sub> (mutagenic exposure frequency) days/year	350	350

### Site-specific Resident Equation Inputs for Soil (RSL Calculator) \* Input values different from Resident defaults are highlighted

Variable	Resident Soil Default Value	Form-input Value
EF <sub>res-a</sub> (exposure frequency - adult) days/year	350	350
EF <sub>res-c</sub> (exposure frequency - child) days/year	350	350
ET <sub>res</sub> (exposure time) hours/day	24	24
ET <sub>0-2</sub> (mutagenic exposure time) hours/day	24	24
ET <sub>2-6</sub> (mutagenic exposure time) hours/day	24	24
ET <sub>6-16</sub> (mutagenic exposure time) hours/day	24	24
ET <sub>16-26</sub> (mutagenic exposure time) hours/day	24	24
ET <sub>res-a</sub> (adult exposure time) hours/day	24	24
ET <sub>res-c</sub> (child exposure time) hours/day	24	24
THQ (target hazard quotient) unitless	0.1	1
IFS <sub>res-adj</sub> (age-adjusted soil ingestion factor) mg/kg	36750	36750
IFSM <sub>res-adj</sub> (mutagenic age-adjusted soil ingestion factor) mg/kg	166833.3	166833.3
IRS <sub>0-2</sub> (mutagenic soil intake rate) mg/day	200	200
IRS <sub>2-6</sub> (mutagenic soil intake rate) mg/day	200	200
IRS <sub>6-16</sub> (mutagenic soil intake rate) mg/day	100	100
IRS <sub>16-26</sub> (mutagenic soil intake rate) mg/day	100	100
IRS <sub>res-a</sub> (soil intake rate - adult) mg/day	100	100
IRS <sub>res-c</sub> (soil intake rate - child) mg/day	200	200
LT (lifetime) years	70	70
SA <sub>0-2</sub> (mutagenic skin surface area) cm <sup>2</sup> /day	2373	2373
SA <sub>2-6</sub> (mutagenic skin surface area) cm <sup>2</sup> /day	2373	2373
SA <sub>6-16</sub> (mutagenic skin surface area) cm <sup>2</sup> /day	6032	6032
SA <sub>16-26</sub> (mutagenic skin surface area) cm <sup>2</sup> /day	6032	6032
SA <sub>res-a</sub> (skin surface area - adult) cm <sup>2</sup> /day	6032	6032
SA <sub>res-c</sub> (skin surface area - child) cm <sup>2</sup> /day	2373	2373
TR (target risk) unitless	0.000001	0.000001
T <sub>w</sub> (groundwater temperature) Celsius	25	25
Theta <sub>a</sub> (air-filled soil porosity) L <sub>air</sub> /L <sub>soil</sub>	0.28396	0.28396
Theta <sub>w</sub> (water-filled soil porosity) L <sub>water</sub> /L <sub>soil</sub>	0.15	0.15
T (exposure interval) s	819936000	819936000
T (exposure interval) yr	26	26
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.02
U <sub>t</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5
VF <sub>ml</sub> (volitization factor - mass limit) m <sup>3</sup> /kg		. 0

Output generated 19MAR2020:12:56:50

Site-specific

Resident Regional Screening Levels (RSL) for Soil (RSL Calculator)

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; \* = where: nc SL < 100X ca SL; \*\* = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded

																Particulate		Ingestion SL	. Dermal SL	Inhalation SL	Noncarcinogenic SL	Ingestion SL	Dermal SL	Inhalation SL	Noncarcinogenic SL		
																Emission	Volatilization	Child	Child	Child	Child	Adult	Adult	Adult	Adult	Screening	
				Chemical	SF <sub>o</sub>	SF.	IUR	IUR	RfD	RfD	RfC	RfC				Factor	Factor	THQ=1	THQ=1	THQ=1	THI=1	THQ=1	THQ=1	THQ=1	THI=1	Level	
Chemical	CAS Number	Mutagen?	Volatile?	Type	(mg/kg-day)	1 Ref	(ug/m <sup>3</sup> )-1	Ref	(mg/kg-day)	Ref	(mg/m³)	Ref	GIABS	ABS	RBA	(m³/kg)	(m³/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Uranium	NA	No	No	Inorganics		-		-	2.00E-04	Α	4.00E-05	Α	1.00E+00	-	1.00E+00	6.61E+09	-	1.56E+01		2.76E+05	1.56E+01	1.67E+02	-	2.76E+05	1.67E+02	1.56E+01 nc	i i

Output generated 19MAR2020:12:56:50

#### Site-specific Resident Risk for Soil (RSL Calculator)

												Particulate			Ingestio				Ingestio			
												Emission	Volatilization		_	Dermal	Inhalation	Noncarcinogenic		Dermal	Inhalation	Noncarcinogenic
	SF <sub>o</sub>	SF.	IUR	IUR	RfD	RfD	RfC	RfC				Factor	Factor	Concentration	Child	Child	Child	Child	Adult	Adult	Adult	Adult
Chemical	(mg/kg-day) <sup>-1</sup>	Ref	(ug/m <sup>3</sup> ) <sup>-1</sup>	Ref	(mg/kg-day)	Ref	(mg/m <sup>3</sup> )	Ref	GIABS	ABS	RBA	(m³/kg)	(m³/kg)	(mg/kg)	HQ	HQ	HQ	HI	HQ	HQ	HQ	HI
Uranium	-		-		0.0002	Α	0.00004	Α	1	-	1	6610000000	-	21	1.34	-	0.0000762	1.34	0.126	-	0.0000762	0.126

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# ATTACHMENT 2 PROUCL OUTPUT

#### UCL Statistics for Data Sets with Non-Detects

**User Selected Options** 

Date/Time of Computation ProUCL 5.13/23/2020 1:14:24 PM

From File ProUCL inputs\_metals\_rad\_HH&ECO.xls

Full Precision OFF

Confidence Coefficient 95%

Number of Bootstrap Operations 2000

#### **Aluminum**

#### **General Statistics**

Total Number of Observations	8	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	8300	Mean	18663
Maximum	25000	Median	22000
SD	6757	Std. Error of Mean	2389
Coefficient of Variation	0.362	Skewness	-0.666

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### **Normal GOF Test**

Shapiro Wilk Test Statistic	0.829	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.314	Lilliefors GOF Test
5% Lilliefors Critical Value	0.283	Data Not Normal at 5% Significance Level

Data appear Approximate Normal at 5% Significance Level

#### **Assuming Normal Distribution**

95% Normal UCL	95% UCLs (Adjusted for Skewness)
----------------	----------------------------------

95% Student's-t UCL 23188 95% Adjusted-CLT UCL (Chen-1995) 21990 95% Modified-t UCL (Johnson-1978) 23095

#### Gamma GOF Test

Anderson-Darling Gamma GOF Test	0.771	A-D Test Statistic
Data Not Gamma Distributed at 5% Significance Level	0.717	5% A-D Critical Value
Kolmogorov-Smirnov Gamma GOF Test	0.342	K-S Test Statistic
Data Not Gamma Distributed at 5% Significance Level	0.295	5% K-S Critical Value

Data Not Gamma Distributed at 5% Significance Level

#### **Gamma Statistics**

k hat (MLE) 7.087 k star (bias corrected MLE) 4.512

Theta hat (MLE)	2634	Theta star (bias corrected MLE)	4136
nu hat (MLE)	113.4	nu star (bias corrected)	72.2
MLE Mean (bias corrected)	18663	MLE Sd (bias corrected)	8785
		Approximate Chi Square Value (0.05)	53.63
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	49.61

#### **Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)) 25122 95% Adjusted Gamma UCL (use when n<50) 27161

#### **Lognormal GOF Test**

Shapiro Wilk Lognormal GOF Test	0.814	Shapiro Wilk Test Statistic
Data Not Lognormal at 5% Significance Level	0.818	5% Shapiro Wilk Critical Value
Lilliefors Lognormal GOF Test	0.334	Lilliefors Test Statistic
Data Not Lognormal at 5% Significance Level	0.283	5% Lilliefors Critical Value

#### Data Not Lognormal at 5% Significance Level

#### **Lognormal Statistics**

Minimum of Logged Data	9.024	Mean of logged Data	9.762
Maximum of Logged Data	10.13	SD of logged Data	0.43

#### **Assuming Lognormal Distribution**

95% H-UCL	27405	90% Chebyshev (MVUE) UCL	27456
95% Chebyshev (MVUE) UCL	31371	97.5% Chebyshev (MVUE) UCL	36806
99% Chebyshev (MVUE) UCL	47481		

### Nonparametric Distribution Free UCL Statistics Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

95% CLT UCL 22592	95% Jackknife UCL 23188
95% Standard Bootstrap UCL 22298	95% Bootstrap-t UCL 22525
95% Hall's Bootstrap UCL 21537	95% Percentile Bootstrap UCL 22125
95% BCA Bootstrap UCL 21875	
90% Chebyshev(Mean, Sd) UCL 25829	95% Chebyshev(Mean, Sd) UCL 29075
97.5% Chebyshev(Mean, Sd) UCL 33581	99% Chebyshev(Mean, Sd) UCL 42432

#### Suggested UCL to Use

95% Student's-t UCL 23188

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test
When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

#### Arsenic

	General Statistics		
Total Number of Observations	8	Number of Distinct Observations	8
Number of Detects	7	Number of Non-Detects	1
Number of Distinct Detects	7	Number of Distinct Non-Detects	1
Minimum Detect	2.5	Minimum Non-Detect	4.85
Maximum Detect	6.5	Maximum Non-Detect	4.85
Variance Detects	2.303	Percent Non-Detects	12.5%
Mean Detects	4.957	SD Detects	1.518
Median Detects	5.5	CV Detects	0.306
Skewness Detects	-0.849	Kurtosis Detects	-0.709
Mean of Logged Detects	1.551	SD of Logged Detects	0.36

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.894	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.211	Lilliefors GOF Test
5% Lilliefors Critical Value	0.304	Detected Data appear Normal at 5% Significance Level

#### Detected Data appear Normal at 5% Significance Level

#### Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

0.572	KM Standard Error of Mean	4.7	KM Mean
5.663	95% KM (BCA) UCL	1.487	KM SD
5.675	95% KM (Percentile Bootstrap) UCL	5.783	95% KM (t) UCL
5.7	95% KM Bootstrap t UCL	5.64	95% KM (z) UCL
7.191	95% KM Chebyshev UCL	6.415	90% KM Chebyshev UCL
10.39	99% KM Chebyshev UCL	8.269	97.5% KM Chebyshev UCL

#### Gamma GOF Tests on Detected Observations Only

Anderson-Darling GOF Test	0.522	A-D Test Statistic
Detected data appear Gamma Distributed at 5% Significance Level	0.708	5% A-D Critical Value
Kolmogorov-Smirnov GOF	0.242	K-S Test Statistic
Detected data appear Gamma Distributed at 5% Significance Level	0.312	5% K-S Critical Value

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	10.2	k star (bias corrected MLE)	5.923
Theta hat (MLE)	0.486	Theta star (bias corrected MLE)	0.837
nu hat (MLE)	142.8	nu star (bias corrected)	82.92
Mean (detects)	4.957		

#### Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	2.5	Mean	4.742
Maximum	6.5	Median	5.2
SD	1.531	CV	0.323
k hat (MLE)	9.675	k star (bias corrected MLE)	6.13
Theta hat (MLE)	0.49	Theta star (bias corrected MLE)	0.773
nu hat (MLE)	154.8	nu star (bias corrected)	98.09
Adjusted Level of Significance $(\beta)$	0.0195		
Approximate Chi Square Value (98.09, $\alpha$ )	76.24	Adjusted Chi Square Value (98.09, β)	71.38
95% Gamma Approximate UCL (use when n>=50)	6.1	95% Gamma Adjusted UCL (use when n<50)	6.516

#### Estimates of Gamma Parameters using KM Estimates

Mean (KM)	4.7	SD (KM)	1.487
Variance (KM)	2.21	SE of Mean (KM)	0.572
k hat (KM)	9.995	k star (KM)	6.331
nu hat (KM)	159.9	nu star (KM)	101.3
theta hat (KM)	0.47	theta star (KM)	0.742
80% gamma percentile (KM)	6.158	90% gamma percentile (KM)	7.196
95% gamma percentile (KM)	8.134	99% gamma percentile (KM)	10.09

#### Gamma Kaplan-Meier (KM) Statistics

Approximate Chi Square Value (101.29, α)	/9.0/	Adjusted Chi Square Value (101.29, β)	/4.11
95% Gamma Approximate KM-UCL (use when n>=50)	6.021	95% Gamma Adjusted KM-UCL (use when n<50)	6.423

#### Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.849	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.803	Detected Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.257	Lilliefors GOF Test
5% Lilliefors Critical Value	0.304	Detected Data appear Lognormal at 5% Significance Level

#### Detected Data appear Lognormal at 5% Significance Level

#### Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	4.725	Mean in Log Scale	1.499
SD in Original Scale	1.551	SD in Log Scale	0.365
95% t UCL (assumes normality of ROS data)	5.764	95% Percentile Bootstrap UCL	5.525
95% BCA Bootstrap UCL	5.5	95% Bootstrap t UCL	5.702

#### 95% H-UCL (Log ROS) 6.429

#### Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution

KM Mean (logged)	1.489	KM Geo Mean	4.433
KM SD (logged)	0.356	95% Critical H Value (KM-Log)	2.132
KM Standard Error of Mean (logged)	0.138	95% H-UCL (KM -Log)	6.29
KM SD (logged)	0.356	95% Critical H Value (KM-Log)	2.132
KM Standard Error of Mean (logged)	0.138		

#### **DL/2 Statistics**

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	4.641	Mean in Log Scale	1.468
SD in Original Scale	1.666	SD in Log Scale	0.408
95% t UCL (Assumes normality)	5.757	95% H-Stat UCL	6.629

DL/2 is not a recommended method, provided for comparisons and historical reasons

## Nonparametric Distribution Free UCL Statistics Detected Data appear Normal Distributed at 5% Significance Level

#### Suggested UCL to Use

95% KM (t) UCL 5.783

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### Barium

#### **General Statistics**

	Gonoral Glatione	•	
Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	41	Mean	104.6
Maximum	250	Median	80
SD	67.66	Std. Error of Mean	23.92
Coefficient of Variation	0.647	Skewness	1.674

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### Normal GOF Test

Shapiro Wilk Test Statistic	0.832	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level

Lilliefors Test Statistic	0.262	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level	
Data appea	r Normal at 59	% Significance Level	
Ass	suming Norma	l Distribution	
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	149.9	95% Adjusted-CLT UCL (Chen-1995)	159.1
		95% Modified-t UCL (Johnson-1978)	152.3
	Gamma GC	OF Test	
A-D Test Statistic	0.324	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.72	Detected data appear Gamma Distributed at 5% Significance	e Level
K-S Test Statistic	0.232	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.296	Detected data appear Gamma Distributed at 5% Significance	e Level
		buted at 5% Significance Level	
		-	
	Gamma St	atistics	
k hat (MLE)	3.439	k star (bias corrected MLE)	2.232
Theta hat (MLE)	30.43	Theta star (bias corrected MLE)	46.86
nu hat (MLE)	55.02	nu star (bias corrected)	35.72
MLE Mean (bias corrected)	104.6	MLE Sd (bias corrected)	70.02
		Approximate Chi Square Value (0.05)	23.04
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	20.51
Ass	uming Gamma	a Distribution	
95% Approximate Gamma UCL (use when n>=50))	162.2	95% Adjusted Gamma UCL (use when n<50)	182.3
, , , , , , , , , , , , , , , , , , , ,		,	
	Lognormal G	OF Test	
Shapiro Wilk Test Statistic	0.969	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.197	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level	
Data appear	Lognormal at	5% Significance Level	
	Lognormal S	Statistics	
Minimum of Logged Data	3.714	Mean of logged Data	4.498
Maximum of Logged Data	5.521	SD of logged Data	0.571
	·	52 5. 15ggod 2dd	

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

90% Chebyshev (MVUE) UCL 166.7

97.5% Chebyshev (MVUE) UCL 235.2

**Assuming Lognormal Distribution** 

95% H-UCL 180.5

95% Chebyshev (MVUE) UCL 195.4

99% Chebyshev (MVUE) UCL 313.4

#### Nonparametric Distribution Free UCLs

95% CLT UCL	144	95% Jackknife UCL	149.9
95% Standard Bootstrap UCL	141.5	95% Bootstrap-t UCL	209.8
95% Hall's Bootstrap UCL	343.1	95% Percentile Bootstrap UCL	145.4
95% BCA Bootstrap UCL	158.9		
90% Chebyshev(Mean, Sd) UCL	176.4	95% Chebyshev(Mean, Sd) UCL	208.9
97.5% Chebyshev(Mean, Sd) UCL	254	99% Chebyshev(Mean, Sd) UCL	342.7

#### Suggested UCL to Use

95% Student's-t UCL 149.9

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### Selenium

#### **General Statistics**

5	Number of Distinct Observations	8	Total Number of Observations
7	Number of Non-Detects	1	Number of Detects
5	Number of Distinct Non-Detects	1	Number of Distinct Detects

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Selenium was not processed!

#### Vanadium

#### General Statistics

<b>Total Number of Observations</b>	8	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	16	Mean	28.63
Maximum	37	Median	31.5
SD	7.19	Std. Error of Mean	2.542
Coefficient of Variation	0.251	Skewness	-0.746

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal GOF Test

Shapiro Wilk Test Statistic	0.905	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.229	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level	
Data appea	r Normal a	t 5% Significance Level	
	suming Nor	mal Distribution	
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	33.44	95% Adjusted-CLT UCL (Chen-1995)	32.09
		95% Modified-t UCL (Johnson-1978)	33.33
	Gamma	GOF Test	
A-D Test Statistic	0.528	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.716	Detected data appear Gamma Distributed at 5% Significance	e Level
K-S Test Statistic	0.245	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.294	Detected data appear Gamma Distributed at 5% Significance	e Level
Detected data appear	Gamma Di	stributed at 5% Significance Level	
		Statistics	
k hat (MLE)	15.6	k star (bias corrected MLE)	9.832
Theta hat (MLE)	1.835	Theta star (bias corrected MLE)	2.911
nu hat (MLE)	249.6	nu star (bias corrected)	157.3
MLE Mean (bias corrected)	28.63	MLE Sd (bias corrected)	9.129
Adicated Lavel of Circuit and	0.0105	Approximate Chi Square Value (0.05)	129.3
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	122.9
Ass	uming Gan	nma Distribution	
95% Approximate Gamma UCL (use when n>=50))	34.82	95% Adjusted Gamma UCL (use when n<50)	36.64
	Lognorma	I GOF Test	
Shapiro Wilk Test Statistic	0.867	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.235	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level	
Data appear	Lognormal	at 5% Significance Level	
	Lognorma	al Statistics	
Minimum of Logged Data	2.773	Mean of logged Data	3.322
Maximum of Logged Data	3.611	SD of logged Data	0.284
Δεσι	mina I oan	ormal Distribution	
95% H-UCL	35.9	90% Chebyshev (MVUE) UCL	37.37
95% Chebyshev (MVUE) UCL	41.3	97.5% Chebyshev (MVUE) UCL	46.75
99% Chebyshev (MVUE) UCL	57.46		-

#### Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

33.44	95% Jackknife UCL	32.81	95% CLT UCL
32.84	95% Bootstrap-t UCL	32.43	95% Standard Bootstrap UCL
32.38	95% Percentile Bootstrap UCL	31.96	95% Hall's Bootstrap UCL
		31.75	95% BCA Bootstrap UCL
39.71	95% Chebyshev(Mean, Sd) UCL	36.25	90% Chebyshev(Mean, Sd) UCL
53.92	99% Chebyshev(Mean, Sd) UCL	44.5	97.5% Chebyshev(Mean, Sd) UCL

#### Suggested UCL to Use

95% Student's-t UCL 33.44

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

#### Ra-226\_SS

	General Statistics		
Total Number of Observations	9	Number of Distinct Observations	9
		Number of Missing Observations	0
Minimum	1.53	Mean	16.43
Maximum	52.7	Median	2.52
SD	21.59	Std. Error of Mean	7.197
Coefficient of Variation	1.314	Skewness	1.054

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Shapiro Wilk Test Statistic	0.706	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.829	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.375	Lilliefors GOF Test
5% Lilliefors Critical Value	0.274	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

**Assuming Normal Distribution** 

95% Normal UCL 95% UCLs (Adjusted for Skewness)

95% Student's-t UCL	29.81	95% Adjusted-CLT UCL (Chen-1995)	30.97
		95% Modified-t UCL (Johnson-1978)	30.23
	Gamma (	GOF Test	
A-D Test Statistic	1.096	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.761	Data Not Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.315	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.292	Data Not Gamma Distributed at 5% Significance Level	
Data Not Gamm	na Distribute	d at 5% Significance Level	
	Gamma	Statistics	
k hat (MLE)	0.624	k star (bias corrected MLE)	0.49
Theta hat (MLE)	26.33	Theta star (bias corrected MLE)	33.53
nu hat (MLE)	11.23	nu star (bias corrected)	8.82
MLE Mean (bias corrected)	16.43	MLE Sd (bias corrected)	23.47
		Approximate Chi Square Value (0.05)	3.219
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	2.548
Ass	uming Gam	ma Distribution	
95% Approximate Gamma UCL (use when n>=50))	45.02	95% Adjusted Gamma UCL (use when n<50)	56.88
	Lognormal	GOF Test	
Shapiro Wilk Test Statistic	0.787	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.829	Data Not Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.278	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.274	Data Not Lognormal at 5% Significance Level	
Data Not Lo	ognormal at	5% Significance Level	
	Lognorma	Statistics	
Minimum of Logged Data	0.425	Mean of logged Data	1.814
Maximum of Logged Data	3.965	SD of logged Data	1.506
MOXIMUM OF LOGGED DUTCH	0.000	SE OF TOUS GOOD	1.000
Assu	ming Logno	rmal Distribution	
95% H-UCL	204.9	90% Chebyshev (MVUE) UCL	39.52
95% Chebyshev (MVUE) UCL	50.42	97.5% Chebyshev (MVUE) UCL	65.54
99% Chebyshev (MVUE) UCL	95.25		
Nonparame	tric Distributi	on Free UCL Statistics	
Data do not fo	llow a Disce	emible Distribution (0.05)	
Nonnar	ametric Dist	ribution Free UCLs	
95% CLT UCL	28.27	95% Jackknife UCL	29.81
95% Standard Bootstrap UCL	27.43	95% Bootstrap-t UCL	39.2
95% Hall's Bootstrap UCL	24.02	95% Percentile Bootstrap UCL	28.18
95% BCA Bootstrap UCL	30.83	30% Total and Datient Deciding Col	
90% Chebyshev(Mean, Sd) UCL	38.02	95% Chebyshev(Mean, Sd) UCL	47.8
22.12 2.102/31.01(1.102.1, 34) 002		22.8 2.182,61.181,1.1821.1, 30, 302	

#### Suggested UCL to Use

95% Hall's Bootstrap UCL 24.02

#### In Case Bootstrap t and/or Hall's Bootstrap yields an unreasonably large UCL value, use 97.5% or 99% Chebyshev (Mean, Sd) UCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### Ra-226\_SB

	General Statistics		
Total Number of Observations	9	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	2.6	Mean	3.574
Maximum	4.6	Median	3.6
SD	0.525	Std. Error of Mean	0.175
Coefficient of Variation	0.147	Skewness	0.162

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal	GOF	Test

918 Shapiro Wilk GOF Test	0.918	Shapiro Wilk Test Statistic
Data appear Normal at 5% Significance Le	0.829	5% Shapiro Wilk Critical Value
223 Lilliefors GOF Test	0.223	Lilliefors Test Statistic
Data appear Normal at 5% Significance Le	0.274	5% Lilliefors Critical Value

#### Data appear Normal at 5% Significance Level

#### **Assuming Normal Distribution**

95% Normal UCL 95% UCLs (Adjusted for Skewness)		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	3.9	95% Adjusted-CLT UCL (Chen-1995)	3.872
		95% Modified-t UCL (Johnson-1978)	3.901

#### Gamma GOF Test

A-D Test Statistic	0.478	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.721	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.202	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.279	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gar	nma	Stat	tistic	2

k hat (MLE)	51.12	k star (bias corrected MLE)	34.15
Theta hat (MLE)	0.0699	Theta star (bias corrected MLE)	0.105
nu hat (MLE)	920.2	nu star (bias corrected)	614.8
MLE Mean (bias corrected)	3.574	MLE Sd (bias corrected)	0.612
		Approximate Chi Square Value (0.05)	558.3
Adjusted Level of Significance	0.0231	Adjusted Chi Square Value	546.9

#### **Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)) 3.936 95% Adjusted Gamma UCL (use when n<50) 4.018

#### **Lognormal GOF Test**

Shapiro Wilk Test Statistic	0.91	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.829	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.209	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.274	Data appear Lognormal at 5% Significance Level

#### Data appear Lognormal at 5% Significance Level

#### **Lognormal Statistics**

Minimum of Logged Data	0.956	Mean of logged Data	1.264
Maximum of Logged Data	1.526	SD of logged Data	0.15

#### **Assuming Lognormal Distribution**

95% H-UCL	3.951	90% Chebyshev (MVUE) UCL	4.112
95% Chebyshev (MVUE) UCL	4.356	97.5% Chebyshev (MVUE) UCL	4.693
99% Chebyshev (MVUE) UCL	5.357		

## Nonparametric Distribution Free UCL Statistics Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

95% CLT UCL	3.862	95% Jackknife UCL	3.9
95% Standard Bootstrap UCL	3.846	95% Bootstrap-t UCL	3.889
95% Hall's Bootstrap UCL	3.995	95% Percentile Bootstrap UCL	3.852
95% BCA Bootstrap UCL	3.838		
90% Chebyshev(Mean, Sd) UCL	4.099	95% Chebyshev(Mean, Sd) UCL	4.337
97.5% Chebyshev(Mean, Sd) UCL	4.667	99% Chebyshev(Mean, Sd) UCL	5.315

#### Suggested UCL to Use

95% Student's-t UCL 3.9

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### **General Statistics**

<b>Total Number of Observations</b>	3	Number of Distinct Observations	3
		Number of Missing Observations	0
Minimum	1.53	Mean	1.757
Maximum	2.11	Median	1.63
SD	0.31	Std. Error of Mean	0.179
Coefficient of Variation	0.177	Skewness	1.532

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### **Normal GOF Test**

Shapiro Wilk Test Statistic	0.875	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.767	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.325	Lilliefors GOF Test
5% Lilliefors Critical Value	0.425	Data appear Normal at 5% Significance Level

#### Data appear Normal at 5% Significance Level

#### **Assuming Normal Distribution**

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	2.279	95% Adjusted-CLT UCL (Chen-1995)	2.22
		95% Modified-t UCL (Johnson-1978)	2.306

## Gamma GOF Test Not Enough Data to Perform GOF Test

#### **Gamma Statistics**

k hat (MLE)	50.64	k star (bias corrected MLE)	N/A
Theta hat (MLE)	0.0347	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	303.8	nu star (bias corrected)	N/A
LE Mean (bias corrected)	N/A	MLE Sd (bias corrected)	N/A
		Approximate Chi Square Value (0.05)	N/A
sted Level of Significance	N/A	Adjusted Chi Square Value	N/A

#### **Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50))	N/A	95% Adjusted Gamma UCL (use when n<50) N	N/A

#### Lognormal GOF Test

Shapiro Wilk Test Statistic	0.891	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.767	Data appear Lognormal at 5% Significance Level

Lilliefors Test Statistic	0.315	Lilliefors Lognormal GOF Test
		_

5% Lilliefors Critical Value 0.425 Data appear Lognormal at 5% Significance Level

#### Data appear Lognormal at 5% Significance Level

#### **Lognormal Statistics**

Minimum of Logged Data	0.425	Mean of logged Data	0.554
Maximum of Logged Data	0.747	SD of logged Data	0.17

#### **Assuming Lognormal Distribution**

95% H-UCL	2.565	90% Chebyshev (MVUE) UCL	2.272
95% Chebyshev (MVUE) UCL	2.506	97.5% Chebyshev (MVUE) UCL	2.83
99% Chebyshev (MVUE) UCL	3.468		

#### Nonparametric Distribution Free UCL Statistics

#### Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

2.279	95% Jackknife UCL	2.051	95% CLT UCL
N/A	95% Bootstrap-t UCL	N/A	95% Standard Bootstrap UCL
N/A	95% Percentile Bootstrap UCL	N/A	95% Hall's Bootstrap UCL
		N/A	95% BCA Bootstrap UCL
2.537	95% Chebyshev(Mean, Sd) UCL	2.294	90% Chebyshev(Mean, Sd) UCL
3.538	99% Chebyshev(Mean, Sd) UCL	2.875	97.5% Chebyshev(Mean, Sd) UCL

#### Suggested UCL to Use

95% Student's-t UCL 2.279

#### Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### Ra-226\_S32\_SB

	General Statistics		
Total Number of Observations	5	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	3.3	Mean	3.48
Maximum	3.6	Median	3.5
SD	0.13	Std. Error of Mean	0.0583
Coefficient of Variation	0.0375	Skewness	-0.541

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use

## guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

Normal	GOF	Test
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Shapiro Wilk Test Statistic	0.902	Shapiro Wilk GOF Test
5% Shapiro Wilk Critical Value	0.762	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.221	Lilliefors GOF Test
5% Lilliefors Critical Value	0.343	Data appear Normal at 5% Significance Level

#### Data appear Normal at 5% Significance Level

#### **Assuming Normal Distribution**

95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	3.604	95% Adjusted-CLT UCL (Chen-1995)	3.561
		95% Modified-t UCL (Johnson-1978)	3.602

#### Gamma GOF Test

A-D Test Statistic	0.349	Anderson-Darling Gamma GOF Test
5% A-D Critical Value	0.678	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.247	Kolmogorov-Smirnov Gamma GOF Test
5% K-S Critical Value	0.357	Detected data appear Gamma Distributed at 5% Significance Level

#### Detected data appear Gamma Distributed at 5% Significance Level

#### Gamma Statistics

k hat (MLE)	882.7	k star (bias corrected MLE)	353.2
Theta hat (MLE)	0.00394	Theta star (bias corrected MLE)	0.00985
nu hat (MLE)	8827	nu star (bias corrected)	3532
MLE Mean (bias corrected)	3.48	MLE Sd (bias corrected)	0.185
		Approximate Chi Square Value (0.05)	3395
Adjusted Level of Significance	0.0086	Adjusted Chi Square Value	3335

#### **Assuming Gamma Distribution**

#### Lognormal GOF Test

Shapiro Wilk Test Statistic	0.901	Shapiro Wilk Lognormal GOF Test
5% Shapiro Wilk Critical Value	0.762	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.22	Lilliefors Lognormal GOF Test
5% Lilliefors Critical Value	0.343	Data appear Lognormal at 5% Significance Level

#### Data appear Lognormal at 5% Significance Level

#### Lognormal Statistics

Minimum of Logged Data	1.194	Mean of logged Data	1.246
Maximum of Logged Data	1.281	SD of logged Data	0.0377

#### **Assuming Lognormal Distribution**

95% H-UCL	N/A	90% Chebyshev (MVUE) UCL	3.656
95% Chebyshev (MVUE) UCL	3.736	97.5% Chebyshev (MVUE) UCL	3.847
99% Chebyshev (MVUE) UCL	4.064		

## Nonparametric Distribution Free UCL Statistics Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

3.604	95% Jackknife UCL	3.576	95% CLT UCL
N/A	95% Bootstrap-t UCL	N/A	95% Standard Bootstrap UCL
N/A	95% Percentile Bootstrap UCL	N/A	95% Hall's Bootstrap UCL
		N/A	95% BCA Bootstrap UCL
3.734	95% Chebyshev(Mean, Sd) UCL	3.65	90% Chebyshev(Mean, Sd) UCL
4.06	99% Chebyshev(Mean, Sd) UCL	3.844	97.5% Chebyshev(Mean, Sd) UCL

#### Suggested UCL to Use

95% Student's-t UCL 3.604

#### Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.

#### Ra-226\_S33\_SS

	General Statistics		
Total Number of Observations	6	Number of Distinct Observations	6
		Number of Missing Observations	0
Minimum	2.47	Mean	23.77
Maximum	52.7	Median	18.6
SD	23.5	Std. Error of Mean	9.592
Coefficient of Variation	0.989	Skewness	0.285

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### **Normal GOF Test**

Shapiro Wilk Test Statistic 0.815 Shapiro Wilk GOF Test

Lilliefors Test Statistic	0.293	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.325	Data appear Normal at 5% Significance Level	
Data appear	Normal at 5	% Significance Level	
Ass	uming Norma	al Distribution	
95% Normal UCL		95% UCLs (Adjusted for Skewness)	
95% Student's-t UCL	43.09	95% Adjusted-CLT UCL (Chen-1995)	40.74
		95% Modified-t UCL (Johnson-1978)	43.28
	Gamma G	OF Test	
A-D Test Statistic	0.639	Anderson-Darling Gamma GOF Test	
5% A-D Critical Value	0.719	Detected data appear Gamma Distributed at 5% Significance	e Level
K-S Test Statistic	0.279	Kolmogorov-Smirnov Gamma GOF Test	
5% K-S Critical Value	0.343	Detected data appear Gamma Distributed at 5% Significance	e Level
Detected data appear 0	Gamma Distr	ibuted at 5% Significance Level	
	Gamma S	tatistics	
k hat (MLE)	0.818	k star (bias corrected MLE)	0.52
Theta hat (MLE)	29.05	Theta star (bias corrected MLE)	45.69
nu hat (MLE)	9.815	nu star (bias corrected)	6.241
MLE Mean (bias corrected)	23.77	MLE Sd (bias corrected)	32.95
	20.77	Approximate Chi Square Value (0.05)	1.764
Adjusted Level of Significance	0.0122	Adjusted Chi Square Value	1.038
	•	na Distribution	142.0
95% Approximate Gamma UCL (use when n>=50))	84.07	95% Adjusted Gamma UCL (use when n<50)	142.9
	Lognormal (	GOF Test	
Shapiro Wilk Test Statistic	0.804	Shapiro Wilk Lognormal GOF Test	
5% Shapiro Wilk Critical Value	0.788	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.259	Lilliefors Lognormal GOF Test	
5% Lilliefors Critical Value	0.325	Data appear Lognormal at 5% Significance Level	
Data appear L	.ognormal at	5% Significance Level	
	Lognormal	Statistics	
Minimum of Logged Data	0.904	Mean of logged Data	2.445
Maximum of Logged Data	3.965	SD of logged Data	1.479
Acquir	mina Loanes	nal Distribution	
95% H-UCL		90% Chebyshev (MVUE) UCL	70.7
95% Chebyshev (MVUE) UCL	90.9	97.5% Chebyshev (MVUE) UCL	118.9
99% Chebyshev (MVUE) UCL	174	37.3% Chebyshev (MVOE) OCL	110.3
, , ,			

5% Shapiro Wilk Critical Value

0.788

Data appear Normal at 5% Significance Level

Nonparametric Distribution Free UCL Statistics

Data appear to follow a Discernible Distribution at 5% Significance Level

#### Nonparametric Distribution Free UCLs

95% CLT UCL	39.54	95% Jackknife UCL	43.09
95% Standard Bootstrap UCL	38.44	95% Bootstrap-t UCL	40.96
95% Hall's Bootstrap UCL	32.51	95% Percentile Bootstrap UCL	39.32
95% BCA Bootstrap UCL	37.63		
90% Chebyshev(Mean, Sd) UCL	52.54	95% Chebyshev(Mean, Sd) UCL	65.58
97.5% Chebyshev(Mean, Sd) UCL	83.67	99% Chebyshev(Mean, Sd) UCL	119.2

#### Suggested UCL to Use

95% Student's-t UCL 43.09

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

#### Ra-226\_S33\_SB

Genera	I Statistics
Genera	I Statistics

Total Number of Observations	4	Number of Distinct Observations	4
		Number of Missing Observations	0
Minimum	2.6	Mean	3.693
Maximum	4.6	Median	3.785
SD	0.824	Std. Error of Mean	0.412
Coefficient of Variation	0.223	Skewness	-0.662

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

#### **Normal GOF Test**

0.935	Shapiro Wilk GOF Test
0.748	Data appear Normal at 5% Significance Level
0.287	Lilliefors GOF Test
0.375	Data appear Normal at 5% Significance Level
	0.748 0.287

#### Data appear Normal at 5% Significance Level

#### **Assuming Normal Distribution**

95% Normal UCL		95% UCLs (Adjusted for Skewness)		
95% Student's-t UCL 4.662		95% Adjusted-CLT UCL (Chen-1995)	4.224	
		95% Modified-t LICL (Johnson-1978)	4 639	

#### Gamma GOF Test

A-D Test Statistic	0.376	Anderson-Darling Gamma GOF Test		
5% A-D Critical Value	0.657	Detected data appear Gamma Distributed at 5% Significance Leve		
K-S Test Statistic	0.318	Kolmogorov-Smirnov Gamma GOF Test		
5% K-S Critical Value	0.394	Detected data appear Gamma Distributed at 5% Significance Le		
Detected data appear (	Gamma Dist	ributed at 5% Significance Level		
	Gamma S	Statistics		
k hat (MLE)	24.68	k star (bias corrected MLE)	6.338	
Theta hat (MLE)	0.15	Theta star (bias corrected MLE)	0.583	
nu hat (MLE)	197.5	nu star (bias corrected)	50.7	
MLE Mean (bias corrected)	3.693	MLE Sd (bias corrected)	1.467	
		Approximate Chi Square Value (0.05)	35.35	
Adjusted Level of Significance	N/A	Adjusted Chi Square Value	N/A	
Ass	uming Gamr	ma Distribution		
95% Approximate Gamma UCL (use when n>=50))	5.296	95% Adjusted Gamma UCL (use when n<50)	N/A	
	Lognormal	GOF Test		
Shapiro Wilk Test Statistic	0.905	Shapiro Wilk Lognormal GOF Test		
5% Shapiro Wilk Critical Value	0.748	Data appear Lognormal at 5% Significance Level		
Lilliefors Test Statistic	0.318	Lilliefors Lognormal GOF Test		
5% Lilliefors Critical Value	0.375	Data appear Lognormal at 5% Significance Level		
Data appear I	Lognormal a	t 5% Significance Level		
	Lognormal			
Minimum of Logged Data	0.956	Mean of logged Data	1.286	
Maximum of Logged Data	1.526	SD of logged Data	0.239	
		mal Distribution		
95% H-UCL	5.309	90% Chebyshev (MVUE) UCL	5.013	
95% Chebyshev (MVUE) UCL	5.61	97.5% Chebyshev (MVUE) UCL	6.439	
99% Chebyshev (MVUE) UCL	8.066			
Nonnaramet	ric Dietributio	on Free UCL Statistics		
•		istribution at 5% Significance Level		
Data appear to follow a D	iocomibio Di	Salbadon at 5 % Oigninoanto 25701		
Nonpara	ametric Distr	ibution Free UCLs		
95% CLT UCL	4.37	95% Jackknife UCL	4.662	
95% Standard Bootstrap UCL	N/A	95% Bootstrap-t UCL	N/A	
95% Hall's Bootstrap UCL	N/A	95% Percentile Bootstrap UCL	N/A	
95% BCA Bootstrap UCL	N/A		-	
90% Chebyshev(Mean, Sd) UCL	4.928	95% Chebyshev(Mean, Sd) UCL	5.487	
22.12.11.02/31.01(11.02.11, 34) 002		2270 31103 y 3110 1 (1110 311, 304) 3 3 2		

99% Chebyshev(Mean, Sd) UCL

7.79

#### Suggested UCL to Use

6.264

95% Student's-t UCL 4.662

97.5% Chebyshev(Mean, Sd) UCL

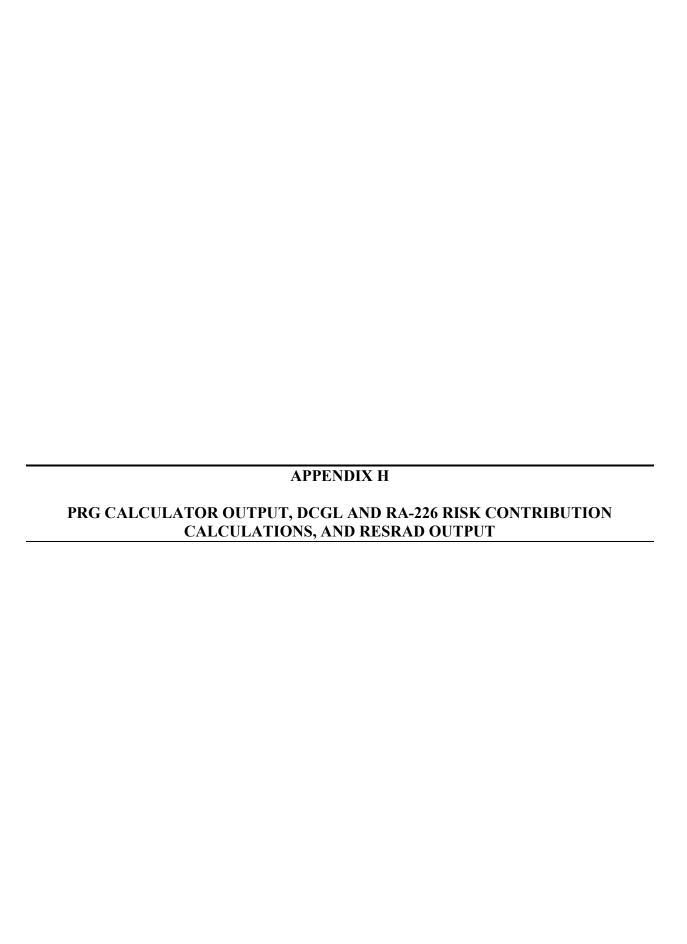
#### Recommended UCL exceeds the maximum observation

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.



#### APPENDIX H

PRG CALCULATOR OUTPUT, DCGL AND RA-226 RISK CONTRIBUTION CALCULATIONS, AND RESRAD OUTPUT

# PRG CALCULATOR OUTPUT RESIDENTIAL WITH 26 YEARS LIFETIME EXPOSURE (EXCLUDES LIVESTOCK MEATS)

Variable	Resident Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
City (Climate Zone)	Default	Albuquerque, NM (3)
C (PEF Dispersion Constant)	216.108	205.1782
CF <sub>res-produce</sub> (contaminated plant fraction) unitless	1	1
CF <sub>res-apple</sub> (contaminated apple fraction) unitless	1	1
CF <sub>res-apparatus</sub> (contaminated asparagus fraction) unitless	1	1
CF <sub>ree-hom</sub> (contaminated berry fraction) unitless	1	1
CF <sub>ree-broccoli</sub> (contaminated broccoli fraction) unitless	1	1
CF <sub>rec.heat</sub> (contaminated beet fraction) unitless	1	1
CF <sub>rec_cabbage</sub> (contaminated cabbage fraction) unitless	1	1
CF <sub>res_careal grain</sub> (contaminated cereal grain fraction) unitless	1	1
CF <sub>res_citrus</sub> (contaminated citrus fraction) unitless	1	1
CF <sub>res_com</sub> (contaminated corn fraction) unitless	1	1
CF <sub>res_carrot</sub> (contaminated carrot fraction) unitless	1	1
CF <sub>res_currimber</sub> (contaminated cucumber fraction) unitless	1	1
CF <sub>rec.lothuce</sub> (contaminated lettuce fraction) unitless	1	1
CF <sub>rec.lima hean</sub> (contaminated lima bean fraction) unitless	1	1
CF <sub>rec.nkra</sub> (contaminated okra fraction) unitless	1	1
CF <sub>res_onion</sub> (contaminated onion fraction) unitless	1	1
CF <sub>rec_nearh</sub> (contaminated peach fraction) unitless	1	1
CF <sub>rec.nea</sub> (contaminated pea fraction) unitless	1	1
CF <sub>res_near</sub> (contaminated pear fraction) unitless	1	1
CF <sub>rec_notato</sub> (contaminated potato fraction) unitless	1	1
CF <sub>ree-pumpkin</sub> (contaminated pumpkin fraction) unitless	1	1
CF <sub>rescrice</sub> (contaminated rice fraction) unitless	1	1
CF <sub>recenan bean</sub> (contaminated snap bean fraction) unitless	1	1
CF <sub>recetrawherry</sub> (contaminated strawberry fraction) unitless	1	1
CF <sub>ree_tomato</sub> (contaminated tomato fraction) unitless	1	1
ED <sub>res-a</sub> (exposure duration - resident adult) yr	20	20

Variable	Resident Soil Default Value	Form-input Value
ED (exposure duration - resident child) yr	6	6
EF <sub>rec.a</sub> (exposure frequency - resident adult) day/yr	350	350
EF <sub>ree_</sub> (exposure frequency - resident child) day/yr	350	350
IFAP <sub>rec-adj</sub> (age-adjusted apple ingestion factor) g	667520	667520
IFAS <sub>rec-adj</sub> (age-adjusted asparagus ingestion factor) g	300300	300300
IFBE <sub>rec-adj</sub> (age-adjusted berry ingestion factor) g	297990	297990
IFBR <sub>recarti</sub> (age-adjusted broccoli ingestion factor) g	251510	251510
IFBT (age-adjusted beet ingestion factor) g	245490	245490
IFCB <sub>recadi</sub> (age-adjusted cabbage ingestion factor) g	670530	670530
IFCG <sub>roc.adf</sub> (age-adjusted cereal grain ingestion factor) g	611800	611800
IFCI <sub>rec.adi</sub> (age-adjusted citrus ingestion factor) g	2573410	2573410
IFCO <sub>rec.adi</sub> (age-adjusted corn ingestion factor) g	468580	468580
IFCR <sub>recardi</sub> (age-adjusted carrot ingestion factor) g	222390	222390
IFCU <sub>rec_adj</sub> (age-adjusted cucumber ingestion factor) g	630140	630140
IFLE recadj (age-adjusted lettuce ingestion factor) g	271320	271320
IFLI recard (age-adjusted lima bean ingestion factor) g	250250	250250
IFOK recadii (age-adjusted okra ingestion factor) g	222530	222530
IFON <sub>recardi</sub> (age-adjusted onion ingestion factor) g	164780	164780
IFPC <sub>roc_adj</sub> (age-adjusted peach ingestion factor) g	1043840	1043840
IFPE <sub>rec.adj</sub> (age-adjusted pea ingestion factor) g	315210	315210
IFPR <sub>recardi</sub> (age-adjusted pear ingestion factor) g	503370	503370
IFPT <sub>recardi</sub> (age-adjusted potato ingestion factor) g	1003170	1003170
IFPU <sub>recadi</sub> (age-adjusted pumpkin ingestion factor) g	548520	548520
IFRI <sub>rec.adj</sub> (age-adjusted rice ingestion factor) g	572880	572880
IFSN <sub>recardi</sub> (age-adjusted snap bean ingestion factor) g	434630	434630
IFST <sub>recardi</sub> (age-adjusted strawberry ingestion factor) g	336630	336630
IFTO <sub>recardi</sub> (age-adjusted tomato ingestion factor) g	624470	624470
IRAP (apple ingestion rate - resident adult) g/day	73.7	73.7
IRAP (apple ingestion rate - resident child) g/day	72.2	72.2
IRAS <sub>res-a</sub> (asparagus ingestion rate - resident adult) g/day	39.3	39.3

Variable	Resident Soil Default Value	Form-input Value
IRAS <sub>mssc</sub> (asparagus ingestion rate - resident child) g/day	12.0	12.0
IRBE resident adult) g/day	35.4	35.4
IRBE resc (berry ingestion rate - resident child) g/day	23.9	23.9
IRBR <sub>resa</sub> (broccoli ingestion rate - resident adult) g/day	32.0	32.0
IRBR (broccoli ingestion rate - resident child) g/day	13.1	13.1
IRBT <sub>ressa</sub> (beet ingestion rate - resident adult) g/day	33.9	33.9
IRBT (beet ingestion rate - resident child) g/day	3.9	3.9
IRCB <sub>resa</sub> (cabbage ingestion rate - resident adult) g/day	92.1	92.1
IRCB <sub>resc</sub> (cabbage ingestion rate - resident child) g/day	12.3	12.3
IRCG <sub>ms.a</sub> (cereal grain ingestion rate - resident adult) g/day	76.0	76.0
IRCG <sub>msc</sub> (cereal grain ingestion rate - resident child) g/day	38.0	38.0
IRCI <sub>res.a</sub> (citrus ingestion rate - resident adult) g/day	309.4	309.4
IRCI (citrus ingestion rate - resident child) g/day	194.1	194.1
IRCO <sub>mes.a</sub> (corn ingestion rate - resident adult) g/day	59.8	59.8
IRCO (corn ingestion rate - resident child) g/day	23.8	23.8
IRCR <sub>me.a</sub> (carrot ingestion rate - resident adult) g/day	27.3	27.3
IRCR <sub>rec.</sub> (carrot ingestion rate - resident child) g/day	14.9	14.9
IRCU <sub>rec.a</sub> (cucumber ingestion rate - resident adult) g/day	82.4	82.4
IRCU <sub>mer.</sub> (cucumber ingestion rate - resident child) g/day	25.4	25.4
IRLE (lettuce ingestion rate - resident adult) g/day	37.5	37.5
IRLE (lettuce ingestion rate - resident child) g/day	4.2	4.2
IRLI <sub>rae.a</sub> (lima bean ingestion rate - resident adult) g/day	33.8	33.8
IRLI resident child) g/day	6.5	6.5
IROK <sub>me.a</sub> (okra ingestion rate - resident adult) g/day	30.2	30.2
IROK <sub>me</sub> (okra ingestion rate - resident child) g/day	5.3	5.3
IRON <sub>rec.a.</sub> (onion ingestion rate - resident adult) g/day	21.8	21.8
IRON (onion ingestion rate - resident child) g/day	5.8	5.8
IRPC <sub>ros.a</sub> (peach ingestion rate - resident adult) g/day	115.7	115.7
IRPC (peach ingestion rate - resident child) g/day	111.4	111.4
IRPE <sub>res-a</sub> (pea ingestion rate - resident adult) g/day	35.4	35.4

Variable	Resident Soil Default Value	Form-input Value
IRPE <sub>rec.</sub> (pea ingestion rate - resident child) g/day	32.1	32.1
IRPR <sub>res.a</sub> (pear ingestion rate - resident adult) g/day	51.9	51.9
IRPR <sub>res_c</sub> (pear ingestion rate - resident child) g/day	66.7	66.7
IRPT <sub>rec.a</sub> (potato ingestion rate - resident adult) g/day	127.8	127.8
IRPT <sub>rec.c.</sub> (potato ingestion rate - resident child) g/day	51.7	51.7
IRPU <sub>res.a</sub> (pumpkin ingestion rate - resident adult) g/day	64.8	64.8
IRPU (pumpkin ingestion rate - resident child) g/day	45.2	45.2
IRRI <sub>me.a</sub> (rice ingestion rate - resident adult) g/day	73.2	73.2
IRRI (rice ingestion rate - resident child) g/day	28.8	28.8
IRSN <sub>rec.a</sub> (snap bean ingestion rate - resident adult) g/day	53.9	53.9
IRSN <sub>ree_</sub> (snap bean ingestion rate - resident child) g/day	27.3	27.3
IRST <sub>rec.a</sub> (strawberry ingestion rate - resident adult) g/day	40.5	40.5
IRST <sub>ree.c.</sub> (strawberry ingestion rate - resident child) g/day	25.3	25.3
IRTO <sub>rec.a</sub> (tomato ingestion rate - resident adult) g/day	80.3	80.3
IRTO (tomato ingestion rate - resident child) g/day	29.7	29.7
MLF <sub>annle</sub> (apple mass loading factor) unitless	0.000160	0.000160
MLF apparagus mass loading factor) unitless	0.0000790	0.0000790
MLF <sub>herry</sub> (berry mass loading factor) unitless	0.000166	0.000166
MLF (broccoli mass loading factor) unitless	0.00101	0.00101
MLF <sub>hoot</sub> (beet mass loading factor) unitless	0.000138	0.000138
MLF <sub>cahbage</sub> (cabbage mass loading factor) unitless	0.000105	0.000105
MLF <sub>cereal grain</sub> (cereal grain mass loading factor) unitless	0.250	0.250
MLF <sub>citrus</sub> (citrus mass loading factor) unitless	0.000157	0.000157
MLF (corn mass loading factor) unitless	0.000145	0.000145
MLF (carrot mass loading factor) unitless	0.0000970	0.0000970
MLF (cucumber mass loading factor) unitless	0.0000400	0.0000400
MLF <sub>lattice</sub> (lettuce mass loading factor) unitless	0.0135	0.0135
MLF <sub>lima bean</sub> (lima bean mass loading factor) unitless	0.00383	0.00383
MLF (okra mass loading factor) unitless	0.0000800	0.0000800
MLF <sub>onion</sub> (onion mass loading factor) unitless	0.0000970	0.0000970

Variable	Resident Soil Default Value	Form-input Value
MLF <sub>mark</sub> (peach mass loading factor) unitless	0.000150	0.000150
MLF (pea mass loading factor) unitless	0.000178	0.000178
MLF (pear mass loading factor) unitless	0.000160	0.000160
MLF (potato mass loading factor) unitless	0.000210	0.000210
MLF (pumpkin mass loading factor) unitless	0.0000580	0.0000580
MLF (rice mass loading factor) unitless	0.250	0.250
MLF (snap bean mass loading factor) unitless	0.00500	0.00500
MLF ctrawberry mass loading factor) unitless	0.0000800	0.0000800
MLF <sub>tomato</sub> (tomato mass loading factor) unitless	0.00159	0.00159
TR (target cancer risk) unitless	1.0E-06	1.0E-04
F(x) (function dependent on U/U,) unitless	0.194	0.0553
PEF (particulate emission factor) m ³/kg	1359344438	6609630249.811598
$Q/C_{wind}$ (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	81.84858572694108
A <sub>c</sub> (acres)	0.5	0.5
ED <sub>res</sub> (exposure duration - resident) yr	26	26
ED <sub>rec.a</sub> (exposure duration - resident adult) yr	20	20
ED <sub>res.r.</sub> (exposure duration - resident child) yr	6	6
EF <sub>ree</sub> (exposure frequency - resident) day/yr	350	350
EF <sub>rec.a</sub> (exposure frequency - resident adult) day/yr	350	350
EF (exposure frequency - resident child) day/yr	350	350
ET <sub>ree</sub> (exposure time - resident) hr/day	24	24
ET <sub>mesa</sub> (exposure time - resident adult) hr/day	24	24
ET <sub>roc.c.</sub> (exposure time - resident child) hr/day	24	24
ET <sub>rae.i</sub> (exposure time - indoor resident) hr/day	16.416	16.416
ET (exposure time - outdoor resident) hr/day	1.752	1.752
GSF, (gamma shielding factor - indoor) unitless	0.4	0.4
IFA <sub>rec.adi</sub> (age-adjusted soil inhalation factor - resident) m <sup>3</sup>	161000	161000
IFS <sub>recadi</sub> (age-adjusted soil ingestion factor - resident) mg	1120000	1120000
IRA <sub>rec.a.</sub> (inhalation rate - resident adult) m <sup>3</sup> /day	20	20
IRA <sub>res-c</sub> (inhalation rate - resident child) m <sup>3</sup> /day	10	10

Variable	Resident Soil Default Value	Form-input Value
IRS <sub>rec.a</sub> (soil intake rate - resident adult) mg/day	100	100
IRS record (soil intake rate - resident child) mg/day	200	200
t <sub>res</sub> (time - resident) yr	26	26
TR (target cancer risk) unitless	1.0E-06	1.0E-04
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.02
U <sub>.</sub> (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

## Site-Specific Resident PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	External Exposure PRG TR=0.0001 (pCi/g)	Produce Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)
*Secular Equilibrium PRG for U-235	6.08E+01	1.31E+04	6.22E+00	-	5.64E+00
*Secular Equilibrium PRG for U-238	1.44E+01	2.84E+04	1.61E+00	-	1.45E+00

Isotope	Parent	Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)
*Secular Equilibrium PRG for U-235	U-235	-		-	-	-	-	-	-	-
Ac-227	U-235	1.00E+00	S	1.49E-07	1.98E-10	2.45E-10	2.90E-10	6.61E+09	3.18E-02	2.18E+01
At-219	U-235	8.28E-07	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.61E+09	3.90E+05	1.78E-06
Bi-211	U-235	1.00E+00	-	0.00E+00	1.90E-07	0.00E+00	0.00E+00	6.61E+09	1.70E+05	4.07E-06
Bi-215	U-235	8.03E-07	-	0.00E+00	1.08E-06	0.00E+00	0.00E+00	6.61E+09	4.79E+04	1.45E-05
Fr-223	U-235	1.38E-02	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	6.61E+09	1.66E+04	4.19E-05
Pa-231	U-235	1.00E+00	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	6.61E+09	2.12E-05	3.28E+04
Pb-211	U-235	1.00E+00	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	6.61E+09	1.01E+04	6.87E-05
Po-211	U-235	2.76E-03	-	0.00E+00	3.76E-08	0.00E+00	0.00E+00	6.61E+09	4.24E+07	1.64E-08
Po-215	U-235	1.00E+00	-	0.00E+00	7.48E-10	0.00E+00	0.00E+00	6.61E+09	1.23E+10	5.65E-11
Ra-223	U-235	1.00E+00	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	6.61E+09	2.21E+01	3.13E-02
Rn-219	U-235	1.00E+00	-	0.00E+00	2.35E-07	0.00E+00	0.00E+00	6.61E+09	5.52E+06	1.26E-07
Th-227	U-235	9.86E-01	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	6.61E+09	1.35E+01	5.12E-02
Th-231	U-235	1.00E+00	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	6.61E+09	2.38E+02	2.91E-03
TI-207	U-235	9.97E-01	-	0.00E+00	1.59E-08	0.00E+00	0.00E+00	6.61E+09	7.64E+04	9.08E-06
U-235	U-235	1.00E+00	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	6.61E+09	9.84E-10	7.04E+08
*Secular Equilibrium PRG for U-238	U-238	-		_	-	-	-	-	-	-
At-218	U-238	2.00E-04	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	6.61E+09	1.46E+07	4.76E-08
Bi-210	U-238	1.00E+00	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	6.61E+09	5.05E+01	1.37E-02
Bi-214	U-238	1.00E+00	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	6.61E+09	1.83E+04	3.79E-05
Hg-206	U-238	1.90E-08	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	6.61E+09	4.47E+04	1.55E-05
Pa-234	U-238	1.60E-03	S	1.20E-12	6.62E-06		5.37E-12	6.61E+09	9.06E+02	
Pa-234m	U-238	1.00E+00	-	0.00E+00	9.06E-08	0.00E+00		6.61E+09	3.11E+05	
Pb-210	U-238	1.00E+00	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	6.61E+09	3.12E-02	2.22E+01
Pb-214	U-238	1.00E+00	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	6.61E+09	1.36E+04	5.10E-05
Po-210	U-238	1.00E+00	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	6.61E+09	1.83E+00	3.79E-01
Po-214	U-238	1.00E+00	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	6.61E+09	1.33E+11	5.21E-12
Po-218	U-238	1.00E+00	-	1.39E-11	6.84E-15	0.00E+00		6.61E+09	1.17E+05	
Ra-226	U-238	1.00E+00	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	6.61E+09	4.33E-04	1.60E+03

Isotope	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	PRG	Produce Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
*Secular Equilibrium PRG for U-235	-	-	-	6.08E+01	1.31E+04	6.22E+00	-	5.64E+00	-
Ac-227	9.80E-01	1.00E+00	4.00E-01	3.08E+02	2.75E+04	5.95E+04	-	3.03E+02	4.57E-11
At-219	9.00E-01	1.00E+00	4.00E-01	-	-	-	-	-	-
Bi-211	8.50E-01	1.00E+00	4.00E-01	-	-	7.15E+01	-	7.15E+01	3.36E-17
Bi-215	8.36E-01	1.00E+00	4.00E-01	-	-	1.59E+07	-	1.59E+07	5.47E-22
Fr-223	8.13E-01	1.00E+00	4.00E-01	3.83E+05	7.31E+09	7.62E+03	-	7.47E+03	3.50E-18
Pa-231	8.46E-01	1.00E+00	4.00E-01	3.00E+02	5.39E+04	1.07E+02	-	7.90E+01	2.68E-07
Pb-211	8.73E-01	1.00E+00	4.00E-01	9.35E+04	1.02E+08	4.56E+01	-	4.56E+01	8.90E-16
Po-211	8.68E-01	1.00E+00	4.00E-01	-	-	1.28E+05	-	1.28E+05	7.52E-23
Po-215	8.76E-01	1.00E+00	4.00E-01	-	-	1.77E+04	-	1.77E+04	1.93E-24
Ra-223	7.84E-01	1.00E+00	4.00E-01	1.49E+02	1.41E+05	3.24E+01	-	2.66E+01	7.35E-13
Rn-219	8.29E-01	1.00E+00	4.00E-01	-	-	5.95E+01	-	5.95E+01	1.29E-18
Th-227	7.93E-01	1.00E+00	4.00E-01	7.03E+02	1.19E+05	3.33E+01	-	3.18E+01	1.02E-12
Th-231	8.78E-01	1.00E+00	4.00E-01	1.50E+04	2.73E+09	5.30E+02	-	5.12E+02	3.68E-15
TI-207	8.83E-01	1.00E+00	4.00E-01	-	-	8.28E+02	-	8.28E+02	6.35E-18
U-235	7.23E-01	1.00E+00	4.00E-01	6.05E+02	1.64E+05	2.90E+01	-	2.77E+01	1.67E-02
*Secular Equilibrium PRG for U-238	-	-	-	1.44E+01	2.84E+04	1.61E+00	-	1.45E+00	-
At-218	9.00E-01	1.00E+00	4.00E-01	-	-	2.34E+09	-	2.34E+09	1.24E-26
Bi-210	8.04E-01	1.00E+00	4.00E-01	3.72E+03	9.02E+06	5.20E+03	-	2.17E+03	3.73E-15
Bi-214	8.49E-01	1.00E+00	4.00E-01	2.21E+05	6.64E+07	1.86E+00	-	1.86E+00	1.22E-14
Hg-206	8.20E-01	1.00E+00	4.00E-01	-	-	1.54E+09	-	1.54E+09	5.82E-24
Pa-234	8.55E-01	1.00E+00	4.00E-01	1.04E+07	2.14E+12	1.28E+03	-	1.28E+03	3.92E-16
Pa-234m	8.71E-01	1.00E+00	4.00E-01	-	-	1.47E+02	-	1.47E+02	9.94E-18
Pb-210	9.05E-01	1.00E+00	4.00E-01	5.20E+01	2.59E+05	8.63E+03	-	5.17E+01	2.53E-10
Pb-214	8.34E-01	1.00E+00	4.00E-01	1.13E+05	5.28E+07	1.40E+01	-	1.40E+01	2.19E-15
Po-210	8.70E-01	1.00E+00	4.00E-01	2.73E+01	2.83E+05	2.95E+05	-	2.73E+01	8.18E-12
Po-214	8.69E-01	1.00E+00	4.00E-01	-	-	3.46E+04	-	3.46E+04	9.03E-26
Po-218	9.00E-01	1.00E+00	4.00E-01	-	2.95E+08	1.88E+09	-	2.55E+08	1.41E-23
Ra-226	7.27E-01	1.00E+00	4.00E-01	1.32E+02	1.46E+05	6.37E+02	-	1.09E+02	9.27E-09

	Isotope	Parent	Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)
Rn-218		U-238	2.00E-07	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	6.61E+09	6.24E+08	1.11E-09
Rn-222		U-238	1.00E+00	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	6.61E+09	6.62E+01	1.05E-02
Th-230		U-238	1.00E+00	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	6.61E+09	9.19E-06	7.54E+04
Th-234		U-238	1.00E+00	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	6.61E+09	1.05E+01	6.60E-02
TI-206		U-238	1.34E-06	-	0.00E+00	6.11E-09	0.00E+00	0.00E+00	6.61E+09	8.67E+04	7.99E-06
TI-210		U-238	2.10E-04	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	6.61E+09	2.80E+05	2.47E-06
U-234		U-238	1.00E+00	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	6.61E+09	2.82E-06	2.46E+05
U-238		U-238	1.00E+00	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	6.61E+09	1.55E-10	4.47E+09

	Isotope	2000 m <sup>2</sup> Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	External Exposure PRG TR=0.0001 (pCi/g)	Produce Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
Rn-218		8.38E-01	1.00E+00	4.00E-01	-	-	2.04E+10	-	2.04E+10	3.32E-29
Rn-222		8.58E-01	1.00E+00	4.00E-01	-	1.80E+09	7.97E+03	-	7.97E+03	8.17E-16
Th-230		9.62E-01	1.00E+00	4.00E-01	5.37E+02	1.20E+05	1.42E+04	-	5.16E+02	9.41E-08
Th-234		8.04E-01	1.00E+00	4.00E-01	1.43E+03	1.33E+08	8.11E+02	-	5.17E+02	8.36E-14
TI-206		8.23E-01	1.00E+00	4.00E-01	-	-	1.72E+09	-	1.72E+09	2.68E-24
TI-210		8.54E-01	1.00E+00	4.00E-01	-	-	4.81E+03	-	4.81E+03	3.03E-19
U-234		1.00E+00	1.00E+00	4.00E-01	6.02E+02	1.48E+05	4.57E+04	-	5.92E+02	2.72E-07
U-238		1.00E+00	1.00E+00	4.00E-01	6.65E+02	1.74E+05	9.35E+04	-	6.58E+02	4.53E-03

## Site-Specific Resident Risk for Soil - Secular Equilibrium

Isotope	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
*Secular Equilibrium Risk for U-235	6.58E-08	3.06E-10	6.43E-07	_	7.09E-07
*Secular Equilibrium Risk for U-238	6.95E-06	3.53E-09	6.21E-05	_	6.91E-05
*Total Risk	7.02E-06	3.83E-09	6.28E-05	_	6.98E-05

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Soil Ingestion Slope Factor (risk/pCi)	Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	2000 m <sup>2</sup> Soil Volume Area Correction Factor
*Secular Equilibrium Risk for U-235		-	-	-	-	-	-	-	-	-
Ac-227	S	1.49E-07	1.98E-10	2.45E-10	2.90E-10	0.04	6.61E+09	3.18E-02	2.18E+01	9.80E-01
At-219	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.04	6.61E+09	3.90E+05	1.78E-06	9.00E-01
Bi-211	-	0.00E+00	1.90E-07	0.00E+00	0.00E+00	0.04	6.61E+09	1.70E+05	4.07E-06	8.50E-01
Bi-215	-	0.00E+00	1.08E-06	0.00E+00	0.00E+00	0.04	6.61E+09	4.79E+04	1.45E-05	8.36E-01
Fr-223	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	0.04	6.61E+09	1.66E+04	4.19E-05	8.13E-01
Pa-231	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	0.04	6.61E+09	2.12E-05	3.28E+04	8.46E-01
Pb-211	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	0.04	6.61E+09	1.01E+04	6.87E-05	8.73E-01
Po-211	-	0.00E+00	3.76E-08	0.00E+00	0.00E+00	0.04	6.61E+09	4.24E+07	1.64E-08	8.68E-01
Po-215	-	0.00E+00	7.48E-10	0.00E+00	0.00E+00	0.04	6.61E+09	1.23E+10	5.65E-11	8.76E-01
Ra-223	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	0.04	6.61E+09	2.21E+01	3.13E-02	7.84E-01
Rn-219	-	0.00E+00	2.35E-07	0.00E+00	0.00E+00	0.04	6.61E+09	5.52E+06	1.26E-07	8.29E-01
Th-227	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	0.04	6.61E+09	1.35E+01	5.12E-02	7.93E-01
Th-231	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	0.04	6.61E+09	2.38E+02	2.91E-03	8.78E-01
TI-207	-	0.00E+00	1.59E-08	0.00E+00	0.00E+00	0.04	6.61E+09	7.64E+04	9.08E-06	8.83E-01
U-235	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	0.04	6.61E+09	9.84E-10	7.04E+08	7.23E-01
*Secular Equilibrium Risk for U-238		-	-	-	-	_	-	-	-	-
At-218	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	1	6.61E+09	1.46E+07	4.76E-08	9.00E-01
Bi-210	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	1	6.61E+09	5.05E+01	1.37E-02	8.04E-01
Bi-214	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	1	6.61E+09	1.83E+04	3.79E-05	8.49E-01
Hg-206	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	1	6.61E+09	4.47E+04	1.55E-05	8.20E-01
Pa-234	S	1.20E-12	6.62E-06	3.00E-12	5.37E-12	1	6.61E+09	9.06E+02	7.65E-04	8.55E-01
Pa-234m	-	0.00E+00	9.06E-08	0.00E+00	0.00E+00	1	6.61E+09	3.11E+05	2.23E-06	8.71E-01
Pb-210	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	1	6.61E+09	3.12E-02	2.22E+01	9.05E-01
Pb-214	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	1	6.61E+09	1.36E+04	5.10E-05	8.34E-01
Po-210	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	1	6.61E+09	1.83E+00	3.79E-01	8.70E-01
Po-214	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	1	6.61E+09	1.33E+11	5.21E-12	8.69E-01
Po-218	-	1.39E-11	6.84E-15	0.00E+00	0.00E+00	1	6.61E+09	1.17E+05	5.90E-06	9.00E-01
Ra-226	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	1	6.61E+09	4.33E-04	1.60E+03	7.27E-01

0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)	Produce Consumption CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
-	-	-	-	-	-	6.58E-08	3.06E-10	6.43E-07	-	7.09E-07
1.00E+00	4.00E-01	4.48E+01	9.74E-04	3.39E-01	-	1.30E-08	1.46E-10	6.73E-11		1.32E-08
1.00E+00	4.00E-01	4.48E+01	9.74E-04	3.11E-01	-	0.00E+00	0.00E+00	0.00E+00		0.00E+00
1.00E+00		4.48E+01	9.74E-04	2.94E-01	-	0.00E+00	0.00E+00	5.59E-08		5.59E-08
1.00E+00	4.00E-01	4.48E+01	9.74E-04	2.89E-01	-	0.00E+00	0.00E+00	2.51E-13		2.51E-13
1.00E+00	4.00E-01		9.74E-04	2.81E-01	-	1.05E-11	5.47E-16	5.25E-10		5.36E-10
1.00E+00		4.48E+01	9.74E-04	2.92E-01	-	1.33E-08	7.43E-11	3.72E-08		5.06E-08
1.00E+00		4.48E+01	9.74E-04	3.02E-01	-	4.28E-11	3.93E-14	8.77E-08		8.78E-08
1.00E+00		4.48E+01	9.74E-04	3.00E-01		0.00E+00	0.00E+00	3.11E-11	-	3.11E-11
1.00E+00		4.48E+01	9.74E-04	3.03E-01	-	0.00E+00	0.00E+00	2.27E-10	-	2.27E-10
1.00E+00		4.48E+01	9.74E-04	2.71E-01	-		2.84E-11	1.23E-07	-	1.50E-07
1.00E+00		4.48E+01	9.74E-04	2.87E-01		0.00E+00	0.00E+00	6.73E-08		6.73E-08
1.00E+00		4.48E+01	9.74E-04	2.74E-01	-	5.69E-09	3.36E-11	1.20E-07	-	1.26E-07
1.00E+00		4.48E+01	9.74E-04	3.04E-01	-	2.67E-10	1.46E-15	7.55E-09	-	7.82E-09
1.00E+00		4.48E+01	9.74E-04	3.05E-01	-	0.00E+00	0.00E+00	4.83E-09		4.83E-09
1.00E+00	4.00E-01	4.48E+01	9.74E-04	2.50E-01	-	6.61E-09	2.44E-11	1.38E-07	-	1.44E-07
-	-	-	-	-	-	6.95E-06	3.53E-09	6.21E-05	-	6.91E-05
1.00E+00		1.12E+03	2.44E-02	7.78E+00	-	0.00E+00	0.00E+00	4.27E-14		4.27E-14
1.00E+00		1.12E+03	2.44E-02	6.95E+00	-	2.69E-08	1.11E-11	1.92E-08		4.61E-08
1.00E+00	4.00E-01	1.12E+03	2.44E-02	7.33E+00	-	4.52E-10	1.51E-12	5.39E-05		5.39E-05
1.00E+00		1.12E+03	2.44E-02	7.08E+00	-	0.00E+00	0.00E+00	6.50E-14		6.50E-14
1.00E+00		1.12E+03		7.39E+00	-	9.61E-12	4.67E-17	7.83E-08	-	7.83E-08
1.00E+00		1.12E+03	2.44E-02	7.53E+00	-	0.00E+00	0.00E+00	6.82E-07	-	6.82E-07
1.00E+00		1.12E+03	2.44E-02	7.82E+00	-	1.92E-06	3.87E-10	1.16E-08	-	1.93E-06
1.00E+00		1.12E+03		7.21E+00	-	8.87E-10	1.89E-12	7.16E-06		7.16E-06
1.00E+00		1.12E+03		7.52E+00	-	3.67E-06	3.53E-10	3.39E-10		3.67E-06
1.00E+00		1.12E+03	2.44E-02	7.51E+00		0.00E+00	0.00E+00	2.89E-09		2.89E-09
1.00E+00		1.12E+03		7.78E+00		0.00E+00	3.39E-13	5.32E-14		3.92E-13
1.00E+00	4.00E-01	1.12E+03	2.44E-02	6.28E+00	-	7.58E-07	6.86E-10	1.57E-07	-	9.16E-07

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Slope Factor	Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	2000 m <sup>2</sup> Soil Volume Area Correction Factor
Rn-218	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	1	6.61E+09	6.24E+08	1.11E-09	8.38E-01
Rn-222	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	1	6.61E+09	6.62E+01	1.05E-02	8.58E-01
Th-230	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	1	6.61E+09	9.19E-06	7.54E+04	9.62E-01
Th-234	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	1	6.61E+09	1.05E+01	6.60E-02	8.04E-01
TI-206	-	0.00E+00	6.11E-09	0.00E+00	0.00E+00	1	6.61E+09	8.67E+04	7.99E-06	8.23E-01
TI-210	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	1	6.61E+09	2.80E+05	2.47E-06	8.54E-01
U-234	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	1	6.61E+09	2.82E-06	2.46E+05	1.00E+00
U-238	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	1	6.61E+09	1.55E-10	4.47E+09	1.00E+00

0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)	Produce Consumption CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
1.00E+00	4.00E-01	1.12E+03	2.44E-02	7.24E+00	-	0.00E+00	0.00E+00	4.90E-15	-	4.90E-15
1.00E+00	4.00E-01	1.12E+03	2.44E-02	7.41E+00	-	0.00E+00	5.55E-14	1.26E-08	-	1.26E-08
1.00E+00	4.00E-01	1.12E+03	2.44E-02	8.31E+00	-	1.86E-07	8.30E-10	7.03E-09	-	1.94E-07
1.00E+00	4.00E-01	1.12E+03	2.44E-02	6.95E+00	-	7.00E-08	7.50E-13	1.23E-07	-	1.93E-07
1.00E+00	4.00E-01	1.12E+03	2.44E-02	7.11E+00	-	0.00E+00	0.00E+00	5.82E-14	-	5.82E-14
1.00E+00	4.00E-01	1.12E+03	2.44E-02	7.38E+00	_	0.00E+00	0.00E+00	2.08E-08	_	2.08E-08
1.00E+00	4.00E-01	1.12E+03	2.44E-02	8.64E+00	_	1.66E-07	6.78E-10	2.19E-09	_	1.69E-07
1.00E+00	4.00E-01	1.12E+03	2.44E-02	8.64E+00	-	1.50E-07	5.76E-10	1.07E-09	-	1.52E-07

# DCGL AND RA-226 RISK CONTRIBUTION CALCULATIONS (RESIDENTIAL WITH 26 YEARS LIFETIME EXPOSURE [EXCLUDLING LIVESTOCK MEATS] ONLY)

## Derived Concentration Guideline Level (DCGL) and Percentage Ra-226 Risk Contribution Calculations Using PRG Calculator Output

(Residential with 26 Years Lifetime Exposure, Excludes Livestock Meats)

	Residential Risk		
Secular Equilibrium Risk		see page 12 of preceding PRG Calculator	
for U-235 and U-238	6.98E-05	Output	
PRG Calculator- Derived DO = Target Cancer Risk (1E-04) 1.43			eline Level)

	<b>Residential Risk</b>	
		see pages
Ra-226	9.16E-07	13 through
Rn-222	1.26E-08	16 of
		preceding
		PRG
At-218	4.27E-14	Calculator
Po-218	3.92E-13	Output
Rn-218	4.90E-15	
Pb-214	7.16E-06	
Bi-214	5.39E-05	
Po-214	2.89E-09	
Risk for Ra-226 through		
Po-214	6.20E-05	

% Contribution of Ra-226 through Po-214 Risk to Total Risk = 89 %

## PRG CALCULATOR OUTPUT

## BACKGROUND RISK FROM RESIDENTIAL WITH 75 YEARS LIFETIME EXPOSURE

(EXCLUDES LIVESTOCK MEATS)

(SEE PAGE 11)

Variable	Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
City (Climate Zone)	Default	Albuquerque, NM (3)
Climate zone	Temperate	Temperate
C (PEF Dispersion Constant)	216.108	205.1782
Cover thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
Cover thickness for GSF , (gamma shielding factor) cm	0 cm	0 cm
CF <sub>rec.produce</sub> (contaminated plant fraction) unitless	1	1
CF <sub>recannel</sub> (contaminated apple fraction) unitless	1	1
CF <sub>recusenaraque</sub> (contaminated asparagus fraction) unitless	1	1
CF <sub>rec.hom.</sub> (contaminated berry fraction) unitless	1	1
CF <sub>rec-broccoli</sub> (contaminated broccoli fraction) unitless	1	1
CF <sub>rec-heat</sub> (contaminated beet fraction) unitless	1	1
CF <sub>rec-rabbage</sub> (contaminated cabbage fraction) unitless	1	1
CF <sub>rec-cereal grain</sub> (contaminated cereal grain fraction) unitless	1	1
CF <sub>rec-citrus</sub> (contaminated citrus fraction) unitless	1	1
CF <sub>recoom</sub> (contaminated corn fraction) unitless	1	1
CF <sub>rec-carrot</sub> (contaminated carrot fraction) unitless	1	1
CF <sub>rec-curumher</sub> (contaminated cucumber fraction) unitless	1	1
CF <sub>rec.lett.ice</sub> (contaminated lettuce fraction) unitless	1	1
CF <sub>rec.lima hean</sub> (contaminated lima bean fraction) unitless	1	1
CF <sub>recokra</sub> (contaminated okra fraction) unitless	1	1
CF <sub>reconion</sub> (contaminated onion fraction) unitless	1	1
CF <sub>rec-peach</sub> (contaminated peach fraction) unitless	1	1
CF <sub>rec.pas</sub> (contaminated pea fraction) unitless	1	1
CF <sub>rec.pear</sub> (contaminated pear fraction) unitless	1	1
CF <sub>rec_notato</sub> (contaminated potato fraction) unitless	1	1
CF <sub>ree_pumpkin</sub> (contaminated pumpkin fraction) unitless	1	1
CF <sub>rec.rica</sub> (contaminated rice fraction) unitless	1	1
CF <sub>recenanhean</sub> (contaminated snap bean fraction) unitless	1	1
CF <sub>recetrawherry</sub> (contaminated strawberry fraction) unitless	1	1
CF <sub>rec.tomato</sub> (contaminated tomato fraction) unitless	1	1
ED <sub>reca</sub> (exposure duration - resident adult) yr	20	69
ED <sub>res-c</sub> (exposure duration - resident child) yr	6	6

Variable	Default Value	Form-input Value
EF <sub>me.a</sub> (exposure frequency - resident adult) day/yr	350	350
EF (exposure frequency - resident child) day/yr	350	350
IFAP <sub>roc.adi</sub> (age-adjusted apple ingestion factor) g	667520	1931475
IFAS <sub>roc.adi</sub> (age-adjusted asparagus ingestion factor) g	300300	974294.9999999999
IFBE <sub>rec.adi</sub> (age-adjusted berry ingestion factor) g	297990	905100
IFBR <sub>rec.adi</sub> (age-adjusted broccoli ingestion factor) g	251510	800310
IFBT <sub>res-arti</sub> (age-adjusted beet ingestion factor) g	245490	826875
IFCB <sub>recardi</sub> (age-adjusted cabbage ingestion factor) g	670530	2250045
IFCG <sub>recarli</sub> (age-adjusted cereal grain ingestion factor) g	611800	611800
IFCI recadi (age-adjusted citrus ingestion factor) g	2573410	7879619.999999999
IFCO <sub>rec.arti</sub> (age-adjusted corn ingestion factor) g	468580	1494150
IFCR <sub>rec.arti</sub> (age-adjusted carrot ingestion factor) g	222390	690585
IFCU <sub>rac.adi</sub> (age-adjusted cucumber ingestion factor) g	630140	2043300.00000000002
IFLE recarii (age-adjusted lettuce ingestion factor) g	271320	914445
IFLI <sub>rec.arti</sub> (age-adjusted lima bean ingestion factor) g	250250	829919.9999999999
IFOK <sub>recarli</sub> (age-adjusted okra ingestion factor) g	222530	740459.9999999999
IFON (age-adjusted onion ingestion factor) g	164780	538650
IFPC <sub>rec.arti</sub> (age-adjusted peach ingestion factor) g	1043840	3028095
IFPE <sub>rec.arti</sub> (age-adjusted pea ingestion factor) g	315210	922320
IFPR <sub>recarli</sub> (age-adjusted pear ingestion factor) g	503370	1393455
IFPT <sub>rec_adj</sub> (age-adjusted potato ingestion factor) g	1003170	3194939.9999999995
IFPU <sub>rec.arti</sub> (age-adjusted pumpkin ingestion factor) g	548520	1659840
IFRI <sub>res.arti</sub> (age-adjusted rice ingestion factor) g	572880	1828260
IFSN <sub>res.arti</sub> (age-adjusted snap bean ingestion factor) g	434630	1359015
IFST <sub>recadi</sub> (age-adjusted strawberry ingestion factor) g	336630	1031205
IFTO <sub>rec.adi</sub> (age-adjusted tomato ingestion factor) g	624470	2001615
IRAP (apple ingestion rate - resident adult) g/day	73.7	73.7
IRAP (apple ingestion rate - resident child) g/day	72.2	72.2
IRAS <sub>rac.a</sub> (asparagus ingestion rate - resident adult) g/day	39.3	39.3
IRAS <sub>ree.</sub> (asparagus ingestion rate - resident child) g/day	12.0	12.0
IRBE <sub>reca</sub> (berry ingestion rate - resident adult) g/day	35.4	35.4
IRBE <sub>rec.</sub> (berry ingestion rate - resident child) g/day	23.9	23.9
IRBR <sub>res.a</sub> (broccoli ingestion rate - resident adult) g/day	32.0	32.0
IRBR <sub>res-c</sub> (broccoli ingestion rate - resident child) g/day	13.1	13.1

Variable	Default Value	Form-input Value
IRBT <sub>res.a</sub> (beet ingestion rate - resident adult) g/day	33.9	33.9
IRBT <sub>res_c</sub> (beet ingestion rate - resident child) g/day	3.9	3.9
IRCB <sub>rec.a.</sub> (cabbage ingestion rate - resident adult) g/day	92.1	92.1
IRCB <sub>rec.</sub> (cabbage ingestion rate - resident child) g/day	12.3	12.3
IRCG <sub>rec.a</sub> (cereal grain ingestion rate - resident adult) g/day	76.0	76.0
IRCG (cereal grain ingestion rate - resident child) g/day	38.0	38.0
IRCI <sub>reca</sub> (citrus ingestion rate - resident adult) g/day	309.4	309.4
IRCI (citrus ingestion rate - resident child) g/day	194.1	194.1
IRCO <sub>raca</sub> (corn ingestion rate - resident adult) g/day	59.8	59.8
IRCO <sub>rec.</sub> (corn ingestion rate - resident child) g/day	23.8	23.8
IRCR <sub>rec.a</sub> (carrot ingestion rate - resident adult) g/day	27.3	27.3
IRCR <sub>rec.r.</sub> (carrot ingestion rate - resident child) g/day	14.9	14.9
IRCU <sub>rec.a</sub> (cucumber ingestion rate - resident adult) g/day	82.4	82.4
IRCU <sub>rec.</sub> (cucumber ingestion rate - resident child) g/day	25.4	25.4
IRLE reca (lettuce ingestion rate - resident adult) g/day	37.5	37.5
IRLE resc (lettuce ingestion rate - resident child) g/day	4.2	4.2
IRLI (lima bean ingestion rate - resident adult) g/day	33.8	33.8
IRLI (lima bean ingestion rate - resident child) g/day	6.5	6.5
IROK <sub>rec.a</sub> (okra ingestion rate - resident adult) g/day	30.2	30.2
IROK (okra ingestion rate - resident child) g/day	5.3	5.3
IRON <sub>rec.a</sub> (onion ingestion rate - resident adult) g/day	21.8	21.8
IRON (onion ingestion rate - resident child) g/day	5.8	5.8
IRPC <sub>resa</sub> (peach ingestion rate - resident adult) g/day	115.7	115.7
IRPC <sub>resc</sub> (peach ingestion rate - resident child) g/day	111.4	111.4
IRPE <sub>rec.a.</sub> (pea ingestion rate - resident adult) g/day	35.4	35.4
IRPE, (pea ingestion rate - resident child) g/day	32.1	32.1
IRPR <sub>reca</sub> (pear ingestion rate - resident adult) g/day	51.9	51.9
IRPR <sub>resc</sub> (pear ingestion rate - resident child) g/day	66.7	66.7
IRPT <sub>ree.a</sub> (potato ingestion rate - resident adult) g/day	127.8	127.8
IRPT <sub>ree_r</sub> (potato ingestion rate - resident child) g/day	51.7	51.7
IRPU <sub>roc.a</sub> (pumpkin ingestion rate - resident adult) g/day	64.8	64.8
IRPU <sub>rec.</sub> (pumpkin ingestion rate - resident child) g/day	45.2	45.2
IRRI <sub>rec.a</sub> (rice ingestion rate - resident adult) g/day	73.2	73.2
IRRI <sub>res-c</sub> (rice ingestion rate - resident child) g/day	28.8	28.8

Variable	Default Value	Form-input Value
IRSN <sub>resa</sub> (snap bean ingestion rate - resident adult) g/day	53.9	53.9
IRSN <sub>resc</sub> (snap bean ingestion rate - resident child) g/day	27.3	27.3
IRST <sub>rec.a</sub> (strawberry ingestion rate - resident adult) g/day	40.5	40.5
IRST <sub>ree,r</sub> (strawberry ingestion rate - resident child) g/day	25.3	25.3
IRTO <sub>res.a</sub> (tomato ingestion rate - resident adult) g/day	80.3	80.3
IRTO <sub>rec.</sub> (tomato ingestion rate - resident child) g/day	29.7	29.7
MLF <sub>annle</sub> (apple mass loading factor) unitless	0.000160	0.000160
MLF (asparagus mass loading factor) unitless	0.0000790	0.0000790
MLF <sub>horn</sub> (berry mass loading factor) unitless	0.000166	0.000166
MLF braccoli (broccoli mass loading factor) unitless	0.00101	0.00101
MLF <sub>hoot</sub> (beet mass loading factor) unitless	0.000138	0.000138
MLF cabbage mass loading factor) unitless	0.000105	0.000105
MLF (cereal grain mass loading factor) unitless	0.250	0.250
MLF (citrus mass loading factor) unitless	0.000157	0.000157
MLF (corn mass loading factor) unitless	0.000145	0.000145
MLF (carrot mass loading factor) unitless	0.0000970	0.0000970
MLF (cucumber mass loading factor) unitless	0.0000400	0.0000400
MLF <sub>Lottuce</sub> (lettuce mass loading factor) unitless	0.0135	0.0135
MLF <sub>lima hean</sub> (lima bean mass loading factor) unitless	0.00383	0.00383
MLF (okra mass loading factor) unitless	0.0000800	0.0000800
MLF onion mass loading factor) unitless	0.0000970	0.0000970
MLF <sub>neach</sub> (peach mass loading factor) unitless	0.000150	0.000150
MLF <sub>nea</sub> (pea mass loading factor) unitless	0.000178	0.000178
MLF <sub>near</sub> (pear mass loading factor) unitless	0.000160	0.000160
MLF (potato mass loading factor) unitless	0.000210	0.000210
MLF (pumpkin mass loading factor) unitless	0.0000580	0.0000580
MLF (rice mass loading factor) unitless	0.250	0.250
MLF <sub>snan hear</sub> (snap bean mass loading factor) unitless	0.00500	0.00500
MLF <sub>strawhorn</sub> (strawberry mass loading factor) unitless	0.0000800	0.0000800
MLF <sub>tomato</sub> (tomato mass loading factor) unitless	0.00159	0.00159
TR (target cancer risk) unitless	1.0E-06	1.0E-04
$F(x)$ (function dependent on U _,/U,) unitless	0.194	0.0553
PEF (particulate emission factor) m ³/kg	1359344438	2370938158.760359
Q/C <sub>wind</sub> (g/m²-s per kg/m³)	93.77	29.359877603759233

## Default Form-input Variable Value Value 0.5 500 A (acres) 1000029 m<sup>2</sup> 1000029 m<sup>2</sup> Site area for ACF (area correction factor) m <sup>2</sup> ED (exposure duration - resident) yr 75 26 69 ED (exposure duration - resident adult) yr 20 ED (exposure duration - resident child) yr 6 6 EF (exposure frequency - resident) day/yr 350 350 EF<sub>195,3</sub> (exposure frequency - resident adult) day/yr 350 350 EF (exposure frequency - resident child) day/yr 350 350 ET (exposure time - resident) hr/day 24 24 ET (exposure time - resident adult) hr/day 24 24 ET (exposure time - resident child) hr/day 24 24 ET\_\_\_ (exposure time - indoor resident) hr/day 16.416 16.416 ET (exposure time - outdoor resident) hr/day 1.752 1.752 GSF (gamma shielding factor - indoor) unitless 0.4 0.4 IFA<sub>resadi</sub> (age-adjusted soil inhalation factor - resident) m <sup>3</sup> 504000 161000 IFS<sub>resadi</sub> (age-adjusted soil ingestion factor - resident) mg 2835000 1120000 IRA (inhalation rate - resident adult) m <sup>3</sup>/day 20 20 IRA (inhalation rate - resident child) m <sup>3</sup>/day 10 10 IRS (soil intake rate - resident adult) mg/day 100 100 IRS (soil intake rate - resident child) mg/day 200 200 75 t\_\_ (time - resident) yr 26 TR (target cancer risk) unitless 1.0E-06 1.0E-04 Soil type Default Default U (mean annual wind speed) m/s 4.69 4.02 U. (equivalent threshold value) 11.32 11.32 0.5 V (fraction of vegetative cover) unitless 0.5

Site-specific
Resident PRGs for Soil - Secular Equilibrium

			External	Produce	
	Ingestion	Inhalation	Exposure	Consumption	Total
	PRG	PRG	PRG	PRG	PRG
	TR=0.0001	TR=0.0001	TR=0.0001	TR=0.0001	TR=0.0001
Isotope	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Secular Equilibrium PRG for U-235	2.40E+01	1.50E+03	1.72E+00	-	1.60E+00
Secular Equilibrium PRG for U-238	5.68E+00	3.25E+03	4.72E-01	-	4.36E-01

Isotope	Parent	Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)
Secular Equilibrium PRG for U-235	U-235	-		-	-	-	-	-	-	-
Ac-227	U-235	1.00E+00	S	1.49E-07	1.98E-10	2.45E-10		2.37E+09	3.18E-02	
At-219	U-235	8.28E-07	-	0.00E+00	0.00E+00	0.00E+00			3.90E+05	
Bi-211	U-235	1.00E+00	-	0.00E+00	1.90E-07	0.00E+00		2.37E+09	1.70E+05	
Bi-215	U-235	8.03E-07	-	0.00E+00	1.08E-06	0.00E+00		2.37E+09	4.79E+04	
Fr-223	U-235	1.38E-02	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	2.37E+09	1.66E+04	
Pa-231	U-235	1.00E+00	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	2.37E+09	2.12E-05	
Pb-211	U-235	1.00E+00	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	2.37E+09	1.01E+04	
Po-211	U-235	2.76E-03	-	0.00E+00	3.76E-08	0.00E+00		2.37E+09	4.24E+07	
Po-215	U-235	1.00E+00	-	0.00E+00	7.48E-10	0.00E+00		2.37E+09	1.23E+10	
Ra-223	U-235	1.00E+00	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	2.37E+09	2.21E+01	
Rn-219	U-235	1.00E+00	-	0.00E+00	2.35E-07	0.00E+00			5.52E+06	
Th-227	U-235	9.86E-01	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	2.37E+09	1.35E+01	
Th-231	U-235	1.00E+00	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	2.37E+09	2.38E+02	
TI-207	U-235	9.97E-01	-	0.00E+00	1.59E-08	0.00E+00		2.37E+09	7.64E+04	
U-235	U-235	1.00E+00	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	2.37E+09	9.84E-10	7.04E+08
Secular Equilibrium PRG for U-238	U-238	-		-	-	-	-	-	-	-
At-218	U-238	2.00E-04	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	2.37E+09	1.46E+07	4.76E-08
Bi-210	U-238	1.00E+00	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	2.37E+09	5.05E+01	1.37E-02
Bi-214	U-238	1.00E+00	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	2.37E+09	1.83E+04	3.79E-05
Hg-206	U-238	1.90E-08	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	2.37E+09	4.47E+04	1.55E-05
Pa-234	U-238	1.60E-03	S	1.20E-12	6.62E-06	3.00E-12	5.37E-12	2.37E+09	9.06E+02	7.65E-04
Pa-234m	U-238	1.00E+00	-	0.00E+00	9.06E-08	0.00E+00	0.00E+00	2.37E+09	3.11E+05	2.23E-06
Pb-210	U-238	1.00E+00	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	2.37E+09	3.12E-02	2.22E+01
Pb-214	U-238	1.00E+00	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	2.37E+09	1.36E+04	5.10E-05
Po-210	U-238	1.00E+00	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	2.37E+09	1.83E+00	3.79E-01
Po-214	U-238	1.00E+00	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	2.37E+09	1.33E+11	5.21E-12
Po-218	U-238	1.00E+00	-	1.39E-11	6.84E-15	0.00E+00	0.00E+00	2.37E+09	1.17E+05	5.90E-06
Ra-226	U-238	1.00E+00	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	2.37E+09	4.33E-04	1.60E+03
Rn-218	U-238	2.00E-07	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	2.37E+09	6.24E+08	1.11E-09
Rn-222	U-238	1.00E+00	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	2.37E+09	6.62E+01	1.05E-02

Isotope	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	PRG	Produce Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
Secular Equilibrium PRG for U-235	-	-	-	2.40E+01	1.50E+03	1.72E+00	-	1.60E+00	-
Ac-227	1.00E+00	1.00E+00		1.22E+02	3.15E+03	2.02E+04	-	1.16E+02	1.19E-10
At-219	9.00E-01	1.00E+00		-	-	-	-	-	-
Bi-211		1.00E+00		-	-	2.11E+01	-	2.11E+01	1.14E-16
Bi-215	1.00E+00	1.00E+00		-	-	4.61E+06	-	4.61E+06	1.89E-21
Fr-223		1.00E+00		1.51E+05	8.38E+08	2.15E+03	-	2.12E+03	1.23E-17
Pa-231		1.00E+00		1.18E+02	6.17E+03	3.15E+01	-	2.48E+01	8.55E-07
Pb-211	1.00E+00	1.00E+00		3.70E+04	1.17E+07	1.38E+01	-	1.38E+01	2.94E-15
Po-211	1.00E+00	1.00E+00		-	-	3.87E+04	-	3.87E+04	2.50E-22
Po-215		1.00E+00		-	-	5.36E+03	-	5.36E+03	6.34E-24
Ra-223	1.00E+00	1.00E+00		5.88E+01	1.61E+04	8.81E+00	-	7.66E+00	2.55E-12
Rn-219		1.00E+00		-	-	1.71E+01	-	1.71E+01	4.50E-18
Th-227		1.00E+00		2.78E+02	1.36E+04	9.14E+00	-	8.85E+00	3.68E-12
Th-231	1.00E+00	1.00E+00		5.92E+03	3.13E+08	1.61E+02	-	1.57E+02	1.20E-14
TI-207		1.00E+00		-	-	2.53E+02	-	2.53E+02	2.08E-17
U-235	1.00E+00	1.00E+00	4.00E-01	2.39E+02	1.88E+04	7.28E+00	-	7.06E+00	6.56E-02
Secular Equilibrium PRG for U-238	-	-	-	5.68E+00	3.25E+03	4.72E-01	-	4.36E-01	-
At-218	9.00E-01	1.00E+00	4.00E-01	-	-	8.12E+08	-	8.12E+08	3.57E-26
Bi-210	1.00E+00	1.00E+00	4.00E-01	1.47E+03	1.03E+06	1.45E+03	-	7.29E+02	1.11E-14
Bi-214	1.00E+00	1.00E+00	4.00E-01	8.75E+04	7.61E+06	5.46E-01	-	5.46E-01	4.15E-14
Hg-206	1.00E+00	1.00E+00	4.00E-01	-	-	4.37E+08	-	4.37E+08	2.05E-23
Pa-234	1.00E+00	1.00E+00	4.00E-01	4.11E+06	2.45E+11	3.79E+02	-	3.79E+02	1.32E-15
Pa-234m	1.00E+00	1.00E+00	4.00E-01	-	-	4.43E+01	-	4.43E+01	3.29E-17
Pb-210	1.00E+00	1.00E+00	4.00E-01	2.05E+01	2.96E+04	2.71E+03	-	2.04E+01	6.41E-10
Pb-214		1.00E+00			6.06E+06	4.04E+00	-	4.04E+00	7.57E-15
Po-210	1.00E+00	1.00E+00	4.00E-01	1.08E+01	3.24E+04	8.90E+04	-	1.08E+01	2.07E-11
Po-214	1.00E+00	1.00E+00	4.00E-01	-	-	1.04E+04	-	1.04E+04	3.00E-25
Po-218	9.00E-01	1.00E+00	4.00E-01	-	3.38E+07	6.51E+08	-	3.22E+07	1.12E-22
Ra-226	1.00E+00	1.00E+00	4.00E-01	5.21E+01	1.67E+04	1.61E+02	-	3.92E+01	2.58E-08
Rn-218	1.00E+00	1.00E+00	4.00E-01	_	-	5.92E+09	-	5.92E+09	1.14E-28
Rn-222	1.00E+00	1.00E+00	4.00E-01	-	2.06E+08	2.37E+03	-	2.37E+03	2.75E-15

	Isotope		Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)
Th-230		U-238	1.00E+00	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	2.37E+09	9.19E-06	7.54E+04
Th-234		U-238	1.00E+00	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	2.37E+09	1.05E+01	6.60E-02
TI-206		U-238	1.34E-06	=	0.00E+00	6.11E-09	0.00E+00	0.00E+00	2.37E+09	8.67E+04	7.99E-06
TI-210		U-238	2.10E-04	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	2.37E+09	2.80E+05	2.47E-06
U-234		U-238	1.00E+00	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	2.37E+09	2.82E-06	2.46E+05
U-238		U-238	1.00E+00	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	2.37E+09	1.55E-10	4.47E+09

Iso	otope	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	External Exposure PRG TR=0.0001 (pCi/g)	Produce Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
Th-230		1.00E+00	1.00E+00	4.00E-01	2.12E+02	1.38E+04	4.75E+03	-	2.00E+02	2.42E-07
Th-234		1.00E+00	1.00E+00	4.00E-01	5.64E+02	1.53E+07	2.26E+02	-	1.61E+02	2.68E-13
TI-206		1.00E+00	1.00E+00	4.00E-01	-	-	4.91E+08	-	4.91E+08	9.39E-24
TI-210		1.00E+00	1.00E+00	4.00E-01	-	-	1.42E+03	-	1.42E+03	1.02E-18
U-234		1.00E+00	1.00E+00	4.00E-01	2.38E+02	1.69E+04	1.58E+04	-	2.31E+02	6.96E-07
U-238		1.00E+00	1.00E+00	4.00E-01	2.63E+02	1.99E+04	3.24E+04	-	2.57E+02	1.16E-02

Site-specific 11

# Site-specific Resident Risk for Soil - Secular Equilibrium

	Ingestion	Inhalation	External Exposure	Produce Consumption	Total
Isotope	Risk	Risk	Risk	Risk	Risk
*Secular Equilibrium Risk for U-235	2.58E-07	4.14E-09	3.60E-06	-	3.87E-06
*Secular Equilibrium Risk for U-238	2.71E-05	4.74E-08	3.26E-04	-	3.53E-04
*Total Risk	2.73E-05	5.15E-08	3.30E-04	-	3.57E-04

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Slope Factor	Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
*Secular Equilibrium Risk for U-235		-	-	-	-	-	-	-	-	-	-
Ac-227	S	1.49E-07	1.98E-10	2.45E-10	2.90E-10	0.062	2.37E+09	3.18E-02	2.18E+01	1.00E+00	1.00E+00
At-219	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.062	2.37E+09	3.90E+05	1.78E-06	9.00E-01	1.00E+00
Bi-211	-	0.00E+00	1.90E-07	0.00E+00	0.00E+00	0.062	2.37E+09	1.70E+05	4.07E-06	1.00E+00	1.00E+00
Bi-215	-	0.00E+00	1.08E-06	0.00E+00	0.00E+00	0.062	2.37E+09	4.79E+04	1.45E-05	1.00E+00	1.00E+00
Fr-223	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	0.062	2.37E+09	1.66E+04	4.19E-05	1.00E+00	1.00E+00
Pa-231	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	0.062	2.37E+09	2.12E-05	3.28E+04	1.00E+00	1.00E+00
Pb-211	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	0.062	2.37E+09	1.01E+04	6.87E-05	1.00E+00	1.00E+00
Po-211	-	0.00E+00	3.76E-08	0.00E+00	0.00E+00	0.062	2.37E+09	4.24E+07	1.64E-08	1.00E+00	1.00E+00
Po-215	-	0.00E+00	7.48E-10	0.00E+00	0.00E+00	0.062	2.37E+09	1.23E+10	5.65E-11	1.00E+00	1.00E+00
Ra-223	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	0.062	2.37E+09	2.21E+01	3.13E-02	1.00E+00	1.00E+00
Rn-219	-	0.00E+00	2.35E-07	0.00E+00	0.00E+00	0.062	2.37E+09	5.52E+06	1.26E-07	1.00E+00	1.00E+00
Th-227	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	0.062	2.37E+09	1.35E+01	5.12E-02	1.00E+00	1.00E+00
Th-231	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	0.062	2.37E+09	2.38E+02	2.91E-03	1.00E+00	1.00E+00
TI-207	-	0.00E+00	1.59E-08	0.00E+00	0.00E+00	0.062	2.37E+09	7.64E+04	9.08E-06	1.00E+00	1.00E+00
U-235	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	0.062	2.37E+09	9.84E-10	7.04E+08	1.00E+00	1.00E+00
*Secular Equilibrium Risk for U-238		-	-	-	-	-	-	-	-	-	-
At-218	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	1.54	2.37E+09	1.46E+07	4.76E-08	9.00E-01	1.00E+00
Bi-210	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	1.54	2.37E+09	5.05E+01	1.37E-02	1.00E+00	1.00E+00
Bi-214	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	1.54	2.37E+09	1.83E+04	3.79E-05	1.00E+00	1.00E+00
Hg-206	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	1.54	2.37E+09	4.47E+04	1.55E-05	1.00E+00	1.00E+00
Pa-234	S	1.20E-12	6.62E-06	3.00E-12	5.37E-12	1.54	2.37E+09	9.06E+02	7.65E-04	1.00E+00	1.00E+00
Pa-234m	-	0.00E+00	9.06E-08	0.00E+00	0.00E+00	1.54	2.37E+09	3.11E+05	2.23E-06	1.00E+00	1.00E+00
Pb-210	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	1.54	2.37E+09	3.12E-02	2.22E+01	1.00E+00	1.00E+00
Pb-214	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	1.54	2.37E+09	1.36E+04	5.10E-05	1.00E+00	1.00E+00
Po-210	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	1.54	2.37E+09	1.83E+00	3.79E-01	1.00E+00	1.00E+00
Po-214	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	1.54	2.37E+09	1.33E+11	5.21E-12	1.00E+00	1.00E+00
Po-218	-	1.39E-11	6.84E-15	0.00E+00	0.00E+00	1.54	2.37E+09	1.17E+05	5.90E-06	9.00E-01	1.00E+00
Ra-226	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	1.54	2.37E+09	4.33E-04	1.60E+03	1.00E+00	1.00E+00

Isotope	Total Indoor GSF Soil Volume	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)	Produce Consumption CDI (pCi)	Risk	Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
*Secular Equilibrium Risk for U-235	-	-	-	-	-	2.58E-07	4.14E-09	3.60E-06	-	3.87E-06
Ac-227 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	5.10E-08	1.97E-09	3.07E-10	-	5.33E-08
At-219 4	4.00E-01	1.76E+02	1.32E-02	1.39E+00	-	0.00E+00	0.00E+00	0.00E+00	-	0.00E+00
Bi-211 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	2.94E-07	-	2.94E-07
Bi-215 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	1.34E-12	-	1.34E-12
Fr-223 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	4.10E-11	7.40E-15	2.89E-09	-	2.93E-09
Pa-231 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	5.24E-08	1.00E-09	1.97E-07	-	2.50E-07
Pb-211 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	1.68E-10	5.32E-13	4.49E-07	-	4.49E-07
Po-211 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	1.60E-10	-	1.60E-10
Po-215 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	1.16E-09	-	1.16E-09
Ra-223 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	1.05E-07	3.85E-10	7.04E-07	-	8.10E-07
Rn-219 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	3.63E-07	-	3.63E-07
Th-227 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	2.23E-08	4.55E-10	6.78E-07	-	7.01E-07
Th-231 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	1.05E-09	1.98E-14	3.84E-08	-	3.95E-08
TI-207 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	0.00E+00	0.00E+00	2.45E-08	-	2.45E-08
U-235 4	4.00E-01	1.76E+02	1.32E-02	1.55E+00	-	2.59E-08	3.30E-10	8.52E-07	-	8.78E-07
*Secular Equilibrium Risk for U-238	-	-	-	-	Ŧ	2.71E-05	4.74E-08	3.26E-04	-	3.53E-04
At-218 4	4.00E-01	4.37E+03	3.27E-01	3.45E+01	-	0.00E+00	0.00E+00	1.90E-13	-	1.90E-13
Bi-210 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	=	1.05E-07	1.49E-10	1.06E-07	-	2.11E-07
Bi-214 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	1.76E-09	2.02E-11	2.82E-04	-	2.82E-04
Hg-206 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	=	0.00E+00	0.00E+00	3.53E-13	-	3.53E-13
Pa-234 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	3.75E-11	6.28E-16	4.07E-07	-	4.07E-07
Pa-234m 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	0.00E+00	3.48E-06	-	3.48E-06
Pb-210 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	7.50E-06	5.20E-09	5.69E-08	-	7.56E-06
Pb-214 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	3.46E-09	2.54E-11	3.81E-05	-	3.81E-05
Po-210 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	1.43E-05	4.75E-09	1.73E-09	-	1.43E-05
Po-214 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	0.00E+00	1.48E-08	-	1.48E-08
Po-218 4	4.00E-01	4.37E+03	3.27E-01	3.45E+01	-	0.00E+00	4.55E-12	2.36E-13	-	4.79E-12
Ra-226 4	4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	2.96E-06	9.22E-09	9.59E-07	-	3.92E-06

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)		Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
Rn-218	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	1.54	2.37E+09	6.24E+08	1.11E-09	1.00E+00	1.00E+00
Rn-222	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	1.54	2.37E+09	6.62E+01	1.05E-02	1.00E+00	1.00E+00
Th-230	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	1.54	2.37E+09	9.19E-06	7.54E+04	1.00E+00	1.00E+00
Th-234	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	1.54	2.37E+09	1.05E+01	6.60E-02	1.00E+00	1.00E+00
TI-206	-	0.00E+00	6.11E-09	0.00E+00	0.00E+00	1.54	2.37E+09	8.67E+04	7.99E-06	1.00E+00	1.00E+00
TI-210	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	1.54	2.37E+09	2.80E+05	2.47E-06	1.00E+00	1.00E+00
U-234	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	1.54	2.37E+09	2.82E-06	2.46E+05	1.00E+00	1.00E+00
U-238	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	1.54	2.37E+09	1.55E-10	4.47E+09	1.00E+00	1.00E+00

	Isotope	Total Indoor GSF Soil Volume	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)	Produce Consumption CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Total Risk
Rn-218		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	0.00E+00	2.60E-14	-	2.60E-14
Rn-222		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	7.46E-13	6.50E-08	-	6.50E-08
Th-230		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	7.25E-07	1.12E-08	3.25E-08	-	7.69E-07
Th-234		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	2.73E-07	1.01E-11	6.81E-07	-	9.54E-07
TI-206		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	0.00E+00	3.14E-13	-	3.14E-13
TI-210		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	0.00E+00	0.00E+00	1.08E-07	-	1.08E-07
U-234		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	6.48E-07	9.11E-09	9.73E-09	-	6.67E-07
U-238		4.00E-01	4.37E+03	3.27E-01	3.84E+01	-	5.86E-07	7.74E-09	4.75E-09	-	5.99E-07

## PRG CALCULATOR OUTPUT

## BACKGROUND RISK FROM RESIDENTIAL WITH 75 YEARS LIFETIME EXPOSURE

(INCLUDES LIVESTOCK MEATS)

(SEE PAGE 14)

Variable	Farmer Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
City (Climate Zone)	Default	Albuquerque, NM (3)
Climate zone	Temperate	Temperate
C (PEF Dispersion Constant)	216.108	205.1782
Cover thickness for GSF (gamma shielding factor) cm	0 cm	0 cm
Cover thickness for GSF , (gamma shielding factor) cm	0 cm	0 cm
CF <sub>far.profuse</sub> (contaminated plant fraction) unitless	1	1
CF <sub>far,annla</sub> (contaminated apple fraction) unitless	1	1
CF <sub>far,aenaraquis</sub> (contaminated asparagus fraction) unitless	1	1
CF <sub>farchoof</sub> (beef contaminated fraction) unitless	1	1
CF <sub>farchern</sub> (contaminated berry fraction) unitless	1	1
CF <sub>fachrocoli</sub> (contaminated broccoli fraction) unitless	1	1
CF <sub>fachaet</sub> (contaminated beet fraction) unitless	1	1
CF <sub>faccabhane</sub> (contaminated cabbage fraction) unitless	1	1
CF <sub>faccereal grain</sub> (contaminated cereal grain fraction) unitless	1	1
CF <sub>farctinus</sub> (contaminated citrus fraction) unitless	1	1
CF <sub>far.com</sub> (contaminated corn fraction) unitless	1	1
CF <sub>faccarrot</sub> (contaminated carrot fraction) unitless	1	1
CF <sub>far-cucumher</sub> (contaminated cucumber fraction) unitless	1	1
CF <sub>factain</sub> (dairy contaminated fraction) unitless	1	1
CF <sub>taceon</sub> (egg contaminated fraction) unitless	1	1
CF <sub>fac,fich</sub> (fish contaminated fraction) unitless	1	1
CF <sub>faconat milk</sub> (goat milk contaminated fraction) unitless	1	1
CF <sub>facoust meat</sub> (goat meat contaminated fraction) unitless	1	1
CF <sub>faculation</sub> (contaminated lettuce fraction) unitless	1	1
CF <sub>far-lima bean</sub> (contaminated lima bean fraction) unitless	1	1
CF <sub>facokra</sub> (contaminated okra fraction) unitless	1	1
CF <sub>far-onion</sub> (contaminated onion fraction) unitless	1	1
CF <sub>far.poviltor</sub> (poultry contaminated fraction unitless)	1	1
CF <sub>far,neach</sub> (contaminated peach fraction) unitless	1	1
CF <sub>far-pea</sub> (contaminated pea fraction) unitless	1	1

Variable	Farmer Soil Default Value	Form-input Value
CF <sub>farmear</sub> (contaminated pear fraction) unitless	1	1
CF <sub>fac.notato</sub> (contaminated potato fraction) unitless	1	1
CF <sub>facuumnkin</sub> (contaminated pumpkin fraction) unitless	1	1
CF <sub>far.rice</sub> (contaminated rice fraction) unitless	1	1
CF <sub>faceheen</sub> (sheep contaminated fraction) unitless	1	1
CF <sub>facehean milk</sub> (sheep milk contaminated fraction) unitless	1	1
CF <sub>far-snan hean</sub> (contaminated snap bean fraction) unitless	1	1
CF <sub>far-strawherry</sub> (contaminated strawberry fraction) unitless	1	1
CF <sub>far.cuine</sub> (swine contaminated fraction) unitless	1	1
CF <sub>factomato</sub> (contaminated tomato fraction) unitless	1	1
ED <sub>far</sub> (exposure duration - farmer) yr	40	75
ED <sub>fara</sub> (exposure duration - farmer adult) yr	34	69
ED (exposure duration - farmer child) yr	6	6
EF <sub>faca</sub> (exposure frequency - farmer adult) day/yr	350	350
EF <sub>face</sub> (exposure frequency - farmer child) day/yr	350	350
IFAP (age-adjusted apple ingestion factor) g	1182020	2219595
IFAS <sub>far-adj</sub> (age-adjusted asparagus ingestion factor) g	492870	974294.9999999999
IFB <sub>far.adi</sub> (age-adjusted beef ingestion factor) g	2098950	4123875.0000000004
IFBE <sub>far.adi</sub> (age-adjusted berry ingestion factor) g	471450	905100
IFBR <sub>far.adj</sub> (age-adjusted broccoli ingestion factor) g	450310	882734.9999999999
IFBT <sub>facadi</sub> (age-adjusted beet ingestion factor) g	411600	826875
IFCB <sub>far.adj</sub> (age-adjusted cabbage ingestion factor) g	1043980	2093805
IFCG <sub>far.arij</sub> (age-adjusted cereal grain ingestion factor) g	1190210	1190210
IFCI <sub>far.arti</sub> (age-adjusted citrus ingestion factor) g	4090100	7880249.999999999
IFCO <sub>far.adi</sub> (age-adjusted corn ingestion factor) g	1044470	2048970
IFCR <sub>far.adj</sub> (age-adjusted carrot ingestion factor) g	318290	617190
IFCU <sub>far.adi</sub> (age-adjusted cucumber ingestion factor) g	688800	1361325
IFD <sub>far,adi</sub> (age-adjusted dairy ingestion factor) g	10138030	18423930
IFE <sub>faradi</sub> (age-adjusted egg ingestion factor) g	775810	1505910.00000000002
IFFI <sub>fac.adj</sub> (age-adjusted fish ingestion factor) g	10018960	20208510
IFLE fanadi (age-adjusted lettuce ingestion factor) g	455070	914445
IFLI <sub>far-adj</sub> (age-adjusted lima bean ingestion factor) g	415870	829919.9999999999

Variable	Farmer Soil Default Value	Form-input Value
IFOK <sub>far.arti</sub> (age-adjusted okra ingestion factor) g	370510	740459.9999999999
IFON <sub>far.adi</sub> (age-adjusted onion ingestion factor) g	338800	672000
IFP <sub>far-arti</sub> (age-adjusted poultry ingestion factor) g	1376550	2692200
IFPC <sub>faradi</sub> (age-adjusted peach ingestion factor) g	1435420	2698395
IFPE <sub>faradi</sub> (age-adjusted pea ingestion factor) g	437500	825824.9999999999
IFPR <sub>faradi</sub> (age-adjusted pear ingestion factor) g	874300	1608074.9999999997
IFPT <sub>far.adi</sub> (age-adjusted potato ingestion factor) g	1807750	3544800.0000000004
IFPU <sub>faradi</sub> (age-adjusted pumpkin ingestion factor) g	866040	1659840
IFRI <sub>far.arti</sub> (age-adjusted rice ingestion factor) g	1126230	2210355
IFSN <sub>faradi</sub> (age-adjusted snap bean ingestion factor) g	702730	1366680
IFST <sub>far-adi</sub> (age-adjusted strawberry ingestion factor) g	535080	1031205
IFSW <sub>farcadi</sub> (age-adjusted swine ingestion factor) g	1171520	2304645
IFTO <sub>forcadi</sub> (age-adjusted tomato ingestion factor) g	1194270	2348220
IRAP <sub>fara</sub> (apple ingestion rate - farmer adult) g/day	84.7	84.7
IRAP <sub>far.c.</sub> (apple ingestion rate - farmer child) g/day	82.9	82.9
IRAS <sub>far.a</sub> (asparagus ingestion rate - farmer adult) g/day	39.3	39.3
IRAS <sub>far.</sub> (asparagus ingestion rate - farmer child) g/day	12.0	12.0
IRB <sub>fara</sub> (beef ingestion rate - farmer adult) g/day	165.3	165.3
IRB <sub>far.</sub> (beef ingestion rate - farmer child) g/day	62.8	62.8
IRBE <sub>far.a</sub> (berry ingestion rate - farmer adult) g/day	35.4	35.4
IRBE <sub>far.c</sub> (berry ingestion rate - farmer child) g/day	23.9	23.9
IRBR <sub>far.a</sub> (broccoli ingestion rate - farmer adult) g/day	35.3	35.3
IRBR <sub>far.c.</sub> (broccoli ingestion rate - farmer child) g/day	14.4	14.4
IRBT <sub>fara</sub> (beet ingestion rate - farmer adult) g/day	33.9	33.9
IRBT <sub>face</sub> (beet ingestion rate - farmer child) g/day	3.9	3.9
IRCB <sub>far.a</sub> (cabbage ingestion rate - farmer adult) g/day	85.7	85.7
IRCB <sub>far.c</sub> (cabbage ingestion rate - farmer child) g/day	11.5	11.5
IRCG <sub>far.a</sub> (cereal grain ingestion rate - farmer adult) g/day	91.9	91.9
IRCG <sub>far.c.</sub> (cereal grain ingestion rate - farmer child) g/day	46.0	46.0
IRCI <sub>far.a</sub> (citrus ingestion rate - farmer adult) g/day	309.4	309.4
IRCI <sub>far.c</sub> (citrus ingestion rate - farmer child) g/day	194.4	194.4
IRCO <sub>far-a</sub> (corn ingestion rate - farmer adult) g/day	82.0	82.0

Variable	Farmer Soil Default Value	Form-input Value
IRCO <sub>farc</sub> (corn ingestion rate - farmer child) g/day	32.7	32.7
IRCR <sub>far.a</sub> (carrot ingestion rate - farmer adult) g/day	24.4	24.4
IRCR <sub>face</sub> (carrot ingestion rate - farmer child) g/day	13.3	13.3
IRCU <sub>fac.a</sub> (cucumber ingestion rate - farmer adult) g/day	54.9	54.9
IRCU <sub>face</sub> (cucumber ingestion rate - farmer child) g/day	16.9	16.9
IRD <sub>far.a</sub> (dairy ingestion rate - farmer adult) g/day	676.4	676.4
IRD <sub>far.c</sub> (dairy ingestion rate - farmer child) g/day	994.7	994.7
IRE <sub>far.a</sub> (egg ingestion rate - farmer adult) g/day	59.6	59.6
IRE <sub>far.c</sub> (egg ingestion rate - farmer child) g/day	31.7	31.7
IRFI <sub>face</sub> (fish ingestion rate - farmer adult) g/day	831.8	831.8
IRFI <sub>face</sub> (fish ingestion rate - farmer child) g/day	57.4	57.4
IRLE far.a (lettuce ingestion rate - farmer adult) g/day	37.5	37.5
IRLE far.c (lettuce ingestion rate - farmer child) g/day	4.2	4.2
IRLI far.a (lima bean ingestion rate - farmer adult) g/day	33.8	33.8
IRLI facc (lima bean ingestion rate - farmer child) g/day	6.5	6.5
IROK <sub>far.a</sub> (okra ingestion rate - farmer adult) g/day	30.2	30.2
IROK <sub>far</sub> (okra ingestion rate - farmer child) g/day	5.3	5.3
IRON <sub>far.a</sub> (onion ingestion rate - farmer adult) g/day	27.2	27.2
IRON <sub>farce</sub> (onion ingestion rate - farmer child) g/day	7.2	7.2
IRP <sub>far.a</sub> (poultry ingestion rate - farmer adult) g/day	107.4	107.4
IRP (poultry ingestion rate - farmer child) g/day	46.9	46.9
IRPC <sub>far.a</sub> (peach ingestion rate - farmer adult) g/day	103.1	103.1
IRPC <sub>far.c</sub> (peach ingestion rate - farmer child) g/day	99.3	99.3
IRPE <sub>far.a</sub> (pea ingestion rate - farmer adult) g/day	31.7	31.7
IRPE <sub>face</sub> (pea ingestion rate - farmer child) g/day	28.7	28.7
IRPR <sub>far.a</sub> (pear ingestion rate - farmer adult) g/day	59.9	59.9
IRPR <sub>far.c</sub> (pear ingestion rate - farmer child) g/day	76.9	76.9
IRPT <sub>fara</sub> (potato ingestion rate - farmer adult) g/day	141.8	141.8
IRPT <sub>fare</sub> (potato ingestion rate - farmer child) g/day	57.3	57.3
IRPU <sub>fara</sub> (pumpkin ingestion rate - farmer adult) g/day	64.8	64.8
IRPU <sub>face</sub> (pumpkin ingestion rate - farmer child) g/day	45.2	45.2
IRRI <sub>far-a</sub> (rice ingestion rate - farmer adult) g/day	88.5	88.5

Variable	Farmer Soil Default Value	Form-input Value
IRRI <sub>face</sub> (rice ingestion rate - farmer child) g/day	34.8	34.8
IRSN <sub>far.a</sub> (snap bean ingestion rate - farmer adult) g/day	54.2	54.2
IRSN <sub>face</sub> (snap bean ingestion rate - farmer child) g/day	27.5	27.5
IRST <sub>far.a</sub> (strawberry ingestion rate - farmer adult) g/day	40.5	40.5
IRST <sub>farce</sub> (strawberry ingestion rate - farmer child) g/day	25.3	25.3
IRSW <sub>far.a</sub> (swine ingestion rate - farmer adult) g/day	92.5	92.5
IRSW <sub>far.c</sub> (swine ingestion rate - farmer child) g/day	33.7	33.7
IRTO <sub>far.a</sub> (tomato ingestion rate - farmer adult) g/day	94.2	94.2
IRTO <sub>fac.</sub> (tomato ingestion rate - farmer child) g/day	34.9	34.9
MLF apple mass loading factor) unitless	0.000160	0.000160
MLF asparagus mass loading factor) unitless	0.0000790	0.0000790
MLF <sub>herry</sub> (berry mass loading factor) unitless	0.000166	0.000166
MLF (broccoli mass loading factor) unitless	0.00101	0.00101
MLF <sub>hoot</sub> (beet mass loading factor) unitless	0.000138	0.000138
MLF <sub>cabbage</sub> (cabbage mass loading factor) unitless	0.000105	0.000105
MLF careal grain mass loading factor) unitless	0.250	0.250
MLF (citrus mass loading factor) unitless	0.000157	0.000157
MLF (corn mass loading factor) unitless	0.000145	0.000145
MLF <sub>carrot</sub> (carrot mass loading factor) unitless	0.0000970	0.0000970
MLF (cucumber mass loading factor) unitless	0.0000400	0.0000400
MLF <sub>lattice</sub> (lettuce mass loading factor) unitless	0.0135	0.0135
MLF <sub>lima bean</sub> (lima bean mass loading factor) unitless	0.00383	0.00383
MLF <sub>okra</sub> (okra mass loading factor) unitless	0.0000800	0.0000800
MLF <sub>onion</sub> (onion mass loading factor) unitless	0.0000970	0.0000970
MLF <sub>mark</sub> (peach mass loading factor) unitless	0.000150	0.000150
MLF <sub>noa</sub> (pea mass loading factor) unitless	0.000178	0.000178
MLF <sub>noar</sub> (pear mass loading factor) unitless	0.000160	0.000160
MLF (potato mass loading factor) unitless	0.000210	0.000210
MLF <sub>pumpkin</sub> (pumpkin mass loading factor) unitless	0.0000580	0.0000580
MLF <sub>rice</sub> (rice mass loading factor) unitless	0.250	0.250
MLF <sub>cnan hean</sub> (snap bean mass loading factor) unitless	0.00500	0.00500
MLF <sub>strawberry</sub> (strawberry mass loading factor) unitless	0.0000800	0.0000800

Variable	Farmer Soil Default Value	Form-input Value
MLF <sub>tomato</sub> (tomato mass loading factor) unitless	0.00159	0.00159
p <sub>m</sub> (density of milk) kg/L	1.03	1.03
t <sub>far</sub> (time - farmer) yr	40	75
TR (target cancer risk) unitless	1.0E-06	1.0E-04
F(x) (function dependent on U/U,) unitless	0.194	0.0553
PEF (particulate emission factor) m <sup>3</sup> /kg	1359344438	6609630249.811598
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	81.84858572694108
A <sub>c</sub> (acres)	0.5	0.5
Slab size for ACF (area correction factor) m <sup>2</sup>	1000029 m <sup>2</sup>	1000029 m <sup>2</sup>
ED <sub>far</sub> (exposure duration - farmer) yr	40	75
ED <sub>far-a</sub> (exposure duration - farmer adult) yr	34	69
ED <sub>far.c</sub> (exposure duration - farmer child) yr	6	6
EF <sub>fr</sub> (exposure frequency) day/yr	350	350
EF <sub>face</sub> (exposure frequency - farmer adult) day/yr	350	350
EF <sub>face</sub> (exposure frequency - farmer child) day/yr	350	350
ET <sub>far</sub> (exposure time - farmer) hr/day	24	24
ET <sub>far.a</sub> (exposure time - farmer adult) hr/day	24	24
ET <sub>face</sub> (exposure time - farmer child) hr/day	24	24
ET <sub>far.i</sub> (indoor exposure time fraction) hr/day	10.008	16.416
ET <sub>far.o.</sub> (outdoor exposure time fraction) hr/day	12.168	1.752
f <sub>s.boof</sub> (animal on-site fraction) unitless	1	1
f <sub>s.dairy</sub> (animal on-site fraction) unitless	1	1
f <sub>n.coat milk</sub> (animal on-site fraction) unitless	1	1
f <sub>nont</sub> (animal on-site fraction) unitless	1	1
f <sub>n,roultry</sub> (animal on-site fraction) unitless	1	1
f <sub>n.sheen</sub> (animal on-site fraction) unitless	1	1
f <sub>n.sheen milk</sub> (animal on-site fraction) unitless	1	1
f <sub>n.swine</sub> (animal on-site fraction) unitless	1	1
f <sub>c_heef</sub> (fraction of year animal on site) unitless	1	1
f <sub>extainy</sub> (fraction of year animal on site) unitless	1	1
f (fraction of year animal on site) unitless	1	1
f <sub>s-goat</sub> (fraction of year animal on site) unitless	1	1

Variable	Farmer Soil Default Value	Form-input Value
f <sub>s_nouthror</sub> (fraction of year animal on site) unitless	1	1
f (fraction of year animal on site) unitless	1	1
f <sub>s.sheen milk</sub> (fraction of year animal on site) unitless	1	1
f <sub>s.swine</sub> (fraction of year animal on site) unitless	1	1
GSF, (gamma shielding factor - indoor)	0.4	0.4
IFA <sub>facadi</sub> (age-adjusted soil inhalation factor) m <sup>-3</sup>	259000	504000
IFS far.adi (age-adjusted soil ingestion factor) mg	1610000	2835000
IRA <sub>far.a</sub> (inhalation rate - farmer adult) m <sup>3</sup> /day	20	20
IRA <sub>far.r</sub> (inhalation rate - farmer child) m <sup>3</sup> /day	10	10
IRS <sub>far-a</sub> (soil ingestion rate - farmer adult) mg/day	100	100
IRS <sub>far.c</sub> (soil ingestion rate - farmer child) mg/day	200	200
MLF <sub>nacture</sub> (pasture plant mass loading factor) unitless	0.25	0.25
Q <sub>n,hoof</sub> (beef fodder intake rate) kg/day	11.77	11.77
Q <sub>rdairy</sub> (dairy fodder intake rate) kg/day	20.3	20.3
Q <sub>runoat milk</sub> (goat milk fodder intake rate) kg/day	1.59	1.59
Q <sub>runnat</sub> (goat fodder intake rate) kg/day	1.27	1.27
Q <sub>r_noulbry</sub> (poultry fodder intake rate) kg/day	0.2	0.2
Q <sub>n-cheen</sub> (sheep fodder intake rate) kg/day	1.75	1.75
Q <sub>n-cheen milk</sub> (sheep milk fodder intake rate) kg/day	3.15	3.15
Q <sub>n.c.wine</sub> (swine fodder intake rate) kg/day	4.7	4.7
Q <sub>c.hoof</sub> (beef soil intake rate) kg/day	0.5	0.5
Q <sub>c.dairy</sub> (dairy soil intake rate) kg/day	0.4	0.4
Q <sub>s.goat milk</sub> (goat milk soil intake rate) kg/day	0.29	0.29
Q <sub>s.goat</sub> (goat soil intake rate) kg/day	0.23	0.23
Q <sub>e_noulbo</sub> (poultry soil intake rate) kg/day	0.022	0.022
Q <sub>c.cheen</sub> (sheep soil intake rate) kg/day	0.32	0.32
Q <sub>s.s.heen milk</sub> (sheep milk soil intake rate) kg/day	0.57	0.57
Q <sub>c.cuine</sub> (swine soil intake rate) kg/day	0.37	0.37
t <sub>far</sub> (time - farmer) yr	40	75
TR (target cancer risk) unitless	1.0E-06	1.0E-04
Default	Default	Default
U <sub>m</sub> (mean annual wind speed) m/s	4.69	4.02

Variable	Farmer Soil Default Value	Form-input Value
U, (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Site-specific
Farmer PRGs for Soil - Secular Equilibrium

			External	Produce	Beef	
	Ingestion	Inhalation	Exposure	Consumption	Consumption	Total
	PRG	PRG	PRG	PRG	PRG	PRG
	TR=0.0001	TR=0.0001	TR=0.0001	TR=0.0001	TR=0.0001	TR=0.0001
Isotope	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Secular Equilibrium PRG for U-235	2.40E+01	4.17E+03	1.72E+00	-	1.03E+01	1.39E+00
Secular Equilibrium PRG for U-238	5.68E+00	9.06E+03	4.72E-01	-	5.32E-01	2.40E-01

Isotope		Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Plant to Beef Transfer Factor (pCi/kg per pCi/d)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
Secular Equilibrium PRG for U-235	U-235	-		-	-	-	-	-	-	-	-	-	-
Ac-227	U-235	1.00E+00	S	1.49E-07	1.98E-10	2.45E-10	2.90E-10	2.00E-05	6.61E+09	3.18E-02	2.18E+01	1.00E+00	1.00E+00
At-219	U-235	8.28E-07	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02	6.61E+09	3.90E+05	1.78E-06	9.00E-01	1.00E+00
Bi-211	U-235	1.00E+00	-	0.00E+00	1.90E-07	0.00E+00	0.00E+00	2.00E-03	6.61E+09	1.70E+05	4.07E-06	1.00E+00	1.00E+00
Bi-215	U-235	8.03E-07	-	0.00E+00	1.08E-06	0.00E+00	0.00E+00	2.00E-03	6.61E+09	4.79E+04	1.45E-05	1.00E+00	1.00E+00
Fr-223	U-235	1.38E-02	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	3.00E-02	6.61E+09	1.66E+04	4.19E-05	1.00E+00	1.00E+00
Pa-231	U-235	1.00E+00	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	5.00E-06	6.61E+09	2.12E-05	3.28E+04	1.00E+00	1.00E+00
Pb-211	U-235	1.00E+00	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	7.00E-04	6.61E+09	1.01E+04	6.87E-05	1.00E+00	1.00E+00
Po-211	U-235	2.76E-03	-	0.00E+00	3.76E-08	0.00E+00	0.00E+00	5.00E-03	6.61E+09	4.24E+07	1.64E-08	1.00E+00	1.00E+00
Po-215	U-235	1.00E+00	-	0.00E+00	7.48E-10	0.00E+00	0.00E+00	5.00E-03	6.61E+09	1.23E+10	5.65E-11	1.00E+00	1.00E+00
Ra-223	U-235	1.00E+00	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	1.70E-03	6.61E+09	2.21E+01	3.13E-02	1.00E+00	1.00E+00
Rn-219	U-235	1.00E+00	-	0.00E+00	2.35E-07	0.00E+00	0.00E+00	0.00E+00	6.61E+09	5.52E+06	1.26E-07	1.00E+00	1.00E+00
Th-227	U-235	9.86E-01	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	2.30E-04	6.61E+09	1.35E+01	5.12E-02	1.00E+00	1.00E+00
Th-231	U-235	1.00E+00	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	2.30E-04	6.61E+09	2.38E+02	2.91E-03	1.00E+00	1.00E+00
TI-207	U-235	9.97E-01	-	0.00E+00	1.59E-08	0.00E+00	0.00E+00	2.00E-02	6.61E+09	7.64E+04	9.08E-06	1.00E+00	1.00E+00
U-235	U-235	1.00E+00	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	3.90E-04	6.61E+09	9.84E-10	7.04E+08	1.00E+00	1.00E+00
Secular Equilibrium PRG for U-238	U-238	-		-	-	-	-	-	-	-	-	-	-
At-218	U-238	2.00E-04	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	1.00E-02	6.61E+09	1.46E+07	4.76E-08	9.00E-01	1.00E+00
Bi-210	U-238	1.00E+00	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	2.00E-03	6.61E+09	5.05E+01	1.37E-02	1.00E+00	1.00E+00
Bi-214	U-238	1.00E+00	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	2.00E-03	6.61E+09	1.83E+04	3.79E-05	1.00E+00	1.00E+00
Hg-206	U-238	1.90E-08	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	1.00E-02	6.61E+09	4.47E+04	1.55E-05	1.00E+00	1.00E+00
Pa-234	U-238	1.60E-03	S	1.20E-12	6.62E-06	3.00E-12	5.37E-12	5.00E-06	6.61E+09	9.06E+02	7.65E-04	1.00E+00	1.00E+00
Pa-234m	U-238	1.00E+00	-	0.00E+00	9.06E-08	0.00E+00	0.00E+00	5.00E-06	6.61E+09	3.11E+05	2.23E-06	1.00E+00	1.00E+00
Pb-210	U-238	1.00E+00	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	7.00E-04	6.61E+09	3.12E-02	2.22E+01	1.00E+00	1.00E+00
Pb-214	U-238	1.00E+00	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	7.00E-04	6.61E+09	1.36E+04	5.10E-05	1.00E+00	1.00E+00
Po-210	U-238	1.00E+00	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	5.00E-03	6.61E+09	1.83E+00	3.79E-01	1.00E+00	1.00E+00

Isotope	Total Indoor GSF Soil Volume	Dry Soil-to-plant transfer factor (pCi/g-fresh plant per pCi/g-dry soil)	K <sub>d</sub> Distribution coefficient (L/kg)	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	PRG	Produce Consumption PRG TR=0.0001 (pCi/g)	Beef Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
Secular Equilibrium PRG for U-235	-	-	-	2.40E+01	4.17E+03	1.72E+00	-	1.03E+01	1.39E+00	-
Ac-227	4.00E-01	1.00E-01	1.70E+03	1.22E+02	8.77E+03	2.02E+04	-	1.07E+03	1.07E+02	1.29E-10
At-219	4.00E-01	9.00E-01	1.00E+01	-	-	-	-	-	-	-
Bi-211	4.00E-01	5.00E-01	4.80E+02	-	-	2.11E+01	-	-	2.11E+01	1.14E-16
Bi-215	4.00E-01	5.00E-01	4.80E+02	-	-	4.61E+06	-	-	4.61E+06	1.89E-21
Fr-223	4.00E-01	1.00E-01	2.50E+02	1.51E+05	2.33E+09	2.15E+03	-	1.26E+03	7.88E+02	3.32E-17
Pa-231	4.00E-01	1.00E-01	2.00E+03	1.18E+02	1.72E+04	3.15E+01	-	4.65E+03	2.47E+01	8.57E-07
Pb-211	4.00E-01	1.26E-02	1.50E+02	3.70E+04	3.25E+07	1.38E+01	-	1.66E+04	1.38E+01	2.94E-15
Po-211	4.00E-01	2.76E-04	2.10E+02	-	-	3.87E+04	-	-	3.87E+04	2.50E-22
Po-215	4.00E-01	2.76E-04	2.10E+02	-	-	5.36E+03	-	-	5.36E+03	6.34E-24
Ra-223	4.00E-01	1.95E-02	1.00E+00	5.88E+01	4.49E+04	8.81E+00	-	1.15E+01	4.59E+00	4.26E-12
Rn-219	4.00E-01	0.00E+00	0.00E+00	-	-	1.71E+01	-	-	1.71E+01	4.50E-18
Th-227	4.00E-01	2.41E-03	2.00E+01	2.78E+02	3.80E+04	9.14E+00	-	4.38E+02	8.68E+00	3.75E-12
Th-231	4.00E-01	2.41E-03	2.00E+01	5.92E+03	8.73E+08	1.61E+02	-	9.45E+03	1.54E+02	1.22E-14
TI-207	4.00E-01	6.00E-01	1.50E+03	-	-	2.53E+02	-	-	2.53E+02	2.08E-17
U-235	4.00E-01	7.13E-03	4.00E-01	2.39E+02	5.24E+04	7.28E+00	-	1.87E+02	6.81E+00	6.81E-02
Secular Equilibrium PRG for U-238	-	-	-	5.68E+00	9.06E+03	4.72E-01	-	5.32E-01	2.40E-01	-
At-218	4.00E-01	9.00E-01	1.00E+01	-	-	8.12E+08	-	-	8.12E+08	3.57E-26
Bi-210	4.00E-01	5.00E-01	4.80E+02	1.47E+03	2.88E+06	1.45E+03	-	9.98E+01	8.78E+01	9.20E-14
Bi-214	4.00E-01	5.00E-01	4.80E+02	8.75E+04	2.12E+07	5.46E-01	-	4.90E+03	5.46E-01	4.15E-14
Hg-206	4.00E-01	1.00E+00	6.30E+03	-	-	4.37E+08	-	-	4.37E+08	2.05E-23
Pa-234	4.00E-01	1.00E-01	2.00E+03	4.11E+06	6.84E+11	3.79E+02	-	2.19E+08	3.79E+02	1.32E-15
Pa-234m	4.00E-01	1.00E-01	2.00E+03	-	-	4.43E+01	-	-	4.43E+01	3.29E-17
Pb-210	4.00E-01	1.26E-02	1.50E+02	2.05E+01	8.26E+04	2.71E+03	-	8.20E+00	5.85E+00	2.23E-09
Pb-214	4.00E-01	1.26E-02	1.50E+02	4.46E+04	1.69E+07	4.04E+00	-	1.99E+04	4.04E+00	7.57E-15
Po-210	4.00E-01	2.76E-04	2.10E+02	1.08E+01	9.04E+04	8.90E+04	-	6.25E-01	5.90E-01	3.78E-10

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Isotope	Parent	Fractional Contribution of Progeny	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Slope Factor	Plant to Beef Transfer Factor (pCi/kg per pCi/d)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor
Po-214	U-238	1.00E+00	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	5.00E-03	6.61E+09	1.33E+11	5.21E-12	1.00E+00	1.00E+00
Po-218	U-238	1.00E+00	-	1.39E-11	6.84E-15	0.00E+00	0.00E+00	5.00E-03	6.61E+09	1.17E+05	5.90E-06	9.00E-01	1.00E+00
Ra-226	U-238	1.00E+00	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	1.70E-03	6.61E+09	4.33E-04	1.60E+03	1.00E+00	1.00E+00
Rn-218	U-238	2.00E-07	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	0.00E+00	6.61E+09	6.24E+08	1.11E-09	1.00E+00	1.00E+00
Rn-222	U-238	1.00E+00	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	0.00E+00	6.61E+09	6.62E+01	1.05E-02	1.00E+00	1.00E+00
Th-230	U-238	1.00E+00	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	2.30E-04	6.61E+09	9.19E-06	7.54E+04	1.00E+00	1.00E+00
Th-234	U-238	1.00E+00	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	2.30E-04	6.61E+09	1.05E+01	6.60E-02	1.00E+00	1.00E+00
TI-206	U-238	1.34E-06	-	0.00E+00	6.11E-09	0.00E+00	0.00E+00	2.00E-02	6.61E+09	8.67E+04	7.99E-06	1.00E+00	1.00E+00
TI-210	U-238	2.10E-04	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	2.00E-02	6.61E+09	2.80E+05	2.47E-06	1.00E+00	1.00E+00
U-234	U-238	1.00E+00	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	3.90E-04	6.61E+09	2.82E-06	2.46E+05	1.00E+00	1.00E+00
U-238	U-238	1.00E+00	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	3.90E-04	6.61E+09	1.55E-10	4.47E+09	1.00E+00	1.00E+00

Isotope	Total Indoor GSF Soil Volume	Dry Soil-to-plant transfer factor (pCi/g-fresh plant per pCi/g-dry soil)	K <sub>a</sub> Distribution coefficient (L/kg)	Ingestion PRG TR=0.0001 (pCi/g)	Inhalation PRG TR=0.0001 (pCi/g)	External Exposure PRG TR=0.0001 (pCi/g)	Produce Consumption PRG TR=0.0001 (pCi/g)	Beef Consumption PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (pCi/g)	Total PRG TR=0.0001 (mg/kg)
Po-214	4.00E-01	2.76E-04	2.10E+02	-	-	1.04E+04	-	-	1.04E+04	3.00E-25
Po-218	4.00E-01	2.76E-04	2.10E+02	-	9.43E+07	6.51E+08	-	-	8.24E+07	4.37E-23
Ra-226	4.00E-01	1.95E-02	1.00E+00	5.21E+01	4.66E+04	1.61E+02	-	7.55E+00	6.33E+00	1.60E-07
Rn-218	4.00E-01	0.00E+00	0.00E+00	-	-	5.92E+09	-	-	5.92E+09	1.14E-28
Rn-222	4.00E-01	0.00E+00	0.00E+00	-	5.75E+08	2.37E+03	-	-	2.37E+03	2.75E-15
Th-230	4.00E-01	2.41E-03	2.00E+01	2.12E+02	3.85E+04	4.75E+03	-	2.55E+02	1.13E+02	4.31E-07
Th-234	4.00E-01	2.41E-03	2.00E+01	5.64E+02	4.26E+07	2.26E+02	-	8.95E+02	1.37E+02	3.16E-13
TI-206	4.00E-01	6.00E-01	1.50E+03	-	-	4.91E+08	-	-	4.91E+08	9.39E-24
TI-210	4.00E-01	6.00E-01	1.50E+03	-	-	1.42E+03	-	-	1.42E+03	1.02E-18
U-234	4.00E-01	7.13E-03	4.00E-01	2.38E+02	4.71E+04	1.58E+04	-	1.85E+02	1.03E+02	1.56E-06
U-238	4.00E-01	7.13E-03	4.00E-01	2.63E+02	5.55E+04	3.24E+04	-	2.04E+02	1.14E+02	2.61E-02

Site-specific 14

# Site-specific Farmer Risk for Soil - Secular Equilibrium

			External	Produce		
	Ingestion	Inhalation	Exposure	Consumption	Beef	Total
Isotope	Risk	Risk	Risk	Risk	Risk	Risk
*Secular Equilibrium Risk for U-235	2.57E-07	1.48E-09	3.58E-06	-	5.97E-07	4.44E-06
*Secular Equilibrium Risk for U-238	2.71E-05	1.70E-08	3.26E-04	-	2.90E-04	6.43E-04
*Total Risk	2.73E-05	1.85E-08	3.30E-04	-	2.90E-04	6.47E-04

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Plant to Beef Transfer Factor (pCi/kg per pCi/d)	Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)
*Secular Equilibrium Risk for U-235		-	-	-	-	-	-	-	-
Ac-227	S	1.49E-07	1.98E-10	2.45E-10	2.90E-10	2.00E-05	0.0616	6.61E+09	3.18E-02
At-219	-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02	0.0616	6.61E+09	3.90E+05
Bi-211	-	0.00E+00	1.90E-07	0.00E+00	0.00E+00	2.00E-03	0.0616	6.61E+09	1.70E+05
Bi-215	-	0.00E+00	1.08E-06	0.00E+00	0.00E+00	2.00E-03	0.0616	6.61E+09	4.79E+04
Fr-223	S	4.07E-11	1.35E-07	1.01E-11	1.69E-11	3.00E-02	0.0616	6.61E+09	1.66E+04
Pa-231	F	7.62E-08	1.27E-07	2.26E-10	2.98E-10	5.00E-06	0.0616	6.61E+09	2.12E-05
Pb-211	S	4.03E-11	2.91E-07	5.81E-13	9.55E-13	7.00E-04	0.0616	6.61E+09	1.01E+04
Po-211	-	0.00E+00	3.76E-08	0.00E+00	0.00E+00	5.00E-03	0.0616	6.61E+09	4.24E+07
Po-215	-	0.00E+00	7.48E-10	0.00E+00	0.00E+00	5.00E-03	0.0616	6.61E+09	1.23E+10
Ra-223	S	2.92E-08	4.55E-07	3.39E-10	5.99E-10	1.70E-03	0.0616	6.61E+09	2.21E+01
Rn-219	-	0.00E+00	2.35E-07	0.00E+00	0.00E+00	0.00E+00	0.0616	6.61E+09	5.52E+06
Th-227	S	3.50E-08	4.45E-07	7.03E-11	1.29E-10	2.30E-04	0.0616	6.61E+09	1.35E+01
Th-231	S	1.50E-12	2.49E-08	3.22E-12	5.96E-12	2.30E-04	0.0616	6.61E+09	2.38E+02
TI-207	-	0.00E+00	1.59E-08	0.00E+00	0.00E+00	2.00E-02	0.0616	6.61E+09	7.64E+04
U-235	S	2.50E-08	5.51E-07	9.44E-11	1.48E-10	3.90E-04	0.0616	6.61E+09	9.84E-10
*Secular Equilibrium Risk for U-238		-	-	-	-	-	-	-	-
At-218	-	0.00E+00	2.74E-11	0.00E+00	0.00E+00	1.00E-02	1.54	6.61E+09	1.46E+07
Bi-210	S	4.55E-10	2.77E-09	1.30E-11	2.40E-11	2.00E-03	1.54	6.61E+09	5.05E+01
Bi-214	S	6.18E-11	7.34E-06	2.65E-13	4.03E-13	2.00E-03	1.54	6.61E+09	1.83E+04
Hg-206	-	0.00E+00	4.83E-07	0.00E+00	0.00E+00	1.00E-02	1.54	6.61E+09	4.47E+04
Pa-234	S	1.20E-12	6.62E-06	3.00E-12	5.37E-12	5.00E-06	1.54	6.61E+09	9.06E+02
Pa-234m	-	0.00E+00	9.06E-08	0.00E+00	0.00E+00	5.00E-06	1.54	6.61E+09	3.11E+05
Pb-210	S	1.59E-08	1.48E-09	1.18E-09	1.72E-09	7.00E-04	1.54	6.61E+09	3.12E-02
Pb-214	S	7.77E-11	9.94E-07	4.85E-13	7.92E-13	7.00E-04	1.54	6.61E+09	1.36E+04
Po-210	S	1.45E-08	4.51E-11	2.25E-09	3.27E-09	5.00E-03	1.54	6.61E+09	1.83E+00
Po-214	-	0.00E+00	3.85E-10	0.00E+00	0.00E+00	5.00E-03	1.54	6.61E+09	1.33E+11
Po-218	-	1.39E-11	6.84E-15	0.00E+00	0.00E+00	5.00E-03	1.54	6.61E+09	1.17E+05
Ra-226	S	2.82E-08	2.50E-08	5.14E-10	6.77E-10	1.70E-03	1.54	6.61E+09	4.33E-04

Isotope	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Dry Soil-to-plant transfer factor (pCi/g-fresh plant per pCi/g-dry soil)	K <sub>d</sub> Distribution coefficient (L/kg)	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)
*Secular Equilibrium Risk for U-235	-	-	-	-	-	-	-	-	-
Ac-227	2.18E+01	1.00E+00	1.00E+00		1.00E-01	1.70E+03	1.75E+02		1.54E+00
At-219	1.78E-06	9.00E-01	1.00E+00		9.00E-01	1.00E+01	1.75E+02		1.38E+00
Bi-211	4.07E-06	1.00E+00	1.00E+00		5.00E-01	4.80E+02	1.75E+02		1.54E+00
Bi-215	1.45E-05		1.00E+00		5.00E-01	4.80E+02	1.75E+02		1.54E+00
Fr-223	4.19E-05	1.00E+00	1.00E+00		1.00E-01	2.50E+02	1.75E+02		1.54E+00
Pa-231	3.28E+04	1.00E+00	1.00E+00		1.00E-01	2.00E+03	1.75E+02		1.54E+00
Pb-211	6.87E-05	1.00E+00	1.00E+00		1.26E-02	1.50E+02	1.75E+02		1.54E+00
Po-211	1.64E-08	1.00E+00	1.00E+00		2.76E-04	2.10E+02	1.75E+02		1.54E+00
Po-215	5.65E-11	1.00E+00	1.00E+00		2.76E-04	2.10E+02	1.75E+02		1.54E+00
Ra-223	3.13E-02	1.00E+00	1.00E+00	4.00E-01	1.95E-02	1.00E+00	1.75E+02	4.70E-03	1.54E+00
Rn-219	1.26E-07	1.00E+00	1.00E+00	4.00E-01	0.00E+00	0.00E+00	1.75E+02	4.70E-03	1.54E+00
Th-227	5.12E-02	1.00E+00	1.00E+00		2.41E-03	2.00E+01	1.75E+02	4.70E-03	1.54E+00
Th-231	2.91E-03	1.00E+00	1.00E+00	4.00E-01	2.41E-03	2.00E+01	1.75E+02	4.70E-03	1.54E+00
TI-207	9.08E-06	1.00E+00	1.00E+00	4.00E-01	6.00E-01	1.50E+03	1.75E+02	4.70E-03	1.54E+00
U-235	7.04E+08	1.00E+00	1.00E+00	4.00E-01	7.13E-03	4.00E-01	1.75E+02	4.70E-03	1.54E+00
*Secular Equilibrium Risk for U-238	-	-	-	-	-	-	-	-	-
At-218	4.76E-08	9.00E-01	1.00E+00		9.00E-01	1.00E+01	4.37E+03	1.17E-01	3.45E+01
Bi-210	1.37E-02	1.00E+00	1.00E+00		5.00E-01	4.80E+02	4.37E+03	1.17E-01	3.84E+01
Bi-214	3.79E-05	1.00E+00	1.00E+00		5.00E-01	4.80E+02	4.37E+03		3.84E+01
Hg-206	1.55E-05	1.00E+00	1.00E+00		1.00E+00	6.30E+03	4.37E+03		3.84E+01
Pa-234	7.65E-04	1.00E+00	1.00E+00	4.00E-01	1.00E-01	2.00E+03	4.37E+03	1.17E-01	3.84E+01
Pa-234m	2.23E-06	1.00E+00	1.00E+00	4.00E-01	1.00E-01	2.00E+03	4.37E+03	1.17E-01	3.84E+01
Pb-210	2.22E+01	1.00E+00	1.00E+00	4.00E-01	1.26E-02	1.50E+02	4.37E+03	1.17E-01	3.84E+01
Pb-214	5.10E-05	1.00E+00	1.00E+00		1.26E-02	1.50E+02	4.37E+03	1.17E-01	3.84E+01
Po-210	3.79E-01	1.00E+00	1.00E+00		2.76E-04	2.10E+02	4.37E+03	1.17E-01	3.84E+01
Po-214	5.21E-12		1.00E+00		2.76E-04	2.10E+02	4.37E+03	1.17E-01	3.84E+01
Po-218	5.90E-06	9.00E-01	1.00E+00		2.76E-04	2.10E+02	4.37E+03	1.17E-01	3.45E+01
Ra-226	1.60E+03	1.00E+00	1.00E+00	4.00E-01	1.95E-02	1.00E+00	4.37E+03	1.17E-01	3.84E+01

Isotope	Produce Consumption CDI (pCi)	Beef CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Beef Risk	Total Risk
*Secular Equilibrium Risk for U-235	-	-	2.57E-07	1.48E-09	3.58E-06	-	5.97E-07	4.44E-06
Ac-227	-	2.35E+01	5.07E-08	7.02E-10	3.05E-10	-	5.76E-09	5.74E-08
At-219	-	3.57E+04	0.00E+00	0.00E+00	0.00E+00	-	0.00E+00	0.00E+00
Bi-211	-	4.74E+03	0.00E+00	0.00E+00	2.92E-07	-	0.00E+00	2.92E-07
Bi-215	-	4.74E+03	0.00E+00	0.00E+00	1.34E-12	-	0.00E+00	1.34E-12
Fr-223	-	3.52E+04	4.08E-11	2.64E-15	2.87E-09	-	4.91E-09	7.82E-09
Pa-231	-	5.87E+00	5.20E-08	3.58E-10	1.95E-07	-	1.32E-09	2.49E-07
Pb-211	-	6.39E+02	1.67E-10	1.89E-13	4.46E-07	-	3.71E-10	4.47E-07
Po-211	-	4.38E+03	0.00E+00	0.00E+00	1.59E-10	-	0.00E+00	1.59E-10
Po-215	-	4.38E+03	0.00E+00	0.00E+00	1.15E-09	-	0.00E+00	1.15E-09
Ra-223	-	1.59E+03	1.05E-07	1.37E-10	6.99E-07	-	5.37E-07	1.34E-06
Rn-219	-	0.00E+00	0.00E+00	0.00E+00	3.60E-07	-	0.00E+00	3.60E-07
Th-227	-	2.03E+02	2.22E-08	1.62E-10	6.74E-07	-	1.41E-08	7.10E-07
Th-231	-	2.03E+02	1.04E-09	7.06E-15	3.82E-08	-	6.52E-10	3.99E-08
TI-207	-	5.34E+04	0.00E+00	0.00E+00	2.43E-08	-	0.00E+00	2.43E-08
U-235	-	3.49E+02	2.58E-08	1.17E-10	8.46E-07	-	3.30E-08	9.05E-07
*Secular Equilibrium Risk for U-238	-	-	2.71E-05	1.70E-08	3.26E-04	-	2.90E-04	6.43E-04
At-218	-	8.91E+05	0.00E+00	0.00E+00	1.90E-13	-	0.00E+00	1.90E-13
Bi-210	-	1.18E+05	1.05E-07	5.34E-11	1.06E-07	-	1.54E-06	1.75E-06
Bi-214	-	1.18E+05	1.76E-09	7.26E-12	2.82E-04	-	3.14E-08	2.82E-04
Hg-206	-	9.66E+05	0.00E+00	0.00E+00	3.53E-13	-	0.00E+00	3.53E-13
Pa-234	-	1.47E+02	3.75E-11	2.25E-16	4.07E-07	-	7.04E-13	4.07E-07
Pa-234m	-	1.47E+02	0.00E+00	0.00E+00	3.48E-06	-	0.00E+00	3.48E-06
Pb-210	-	1.60E+04	7.50E-06	1.86E-09	5.69E-08	-	1.88E-05	2.63E-05
Pb-214	-	1.60E+04	3.46E-09	9.12E-12	3.81E-05	-	7.74E-09	3.81E-05
Po-210	-	1.09E+05	1.43E-05	1.70E-09	1.73E-09	-	2.47E-04	2.61E-04
Po-214	-	1.09E+05	0.00E+00	0.00E+00	1.48E-08	-	0.00E+00	1.48E-08
Po-218	-	1.09E+05	0.00E+00	1.63E-12	2.36E-13	-	0.00E+00	1.87E-12
Ra-226	-	3.96E+04	2.96E-06	3.31E-09	9.59E-07	-	2.04E-05	2.43E-05

Isotope	ICRP Lung Absorption Type	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/yr per pCi/g)	Slope Factor	Soil Ingestion Slope Factor (risk/pCi)	Plant to Beef Transfer Factor (pCi/kg per pCi/d)	Concentration (pCi/g)	Particulate Emission Factor (m³/kg)	Lambda (1/yr)
Rn-218	-	0.00E+00	3.39E-09	0.00E+00	0.00E+00	0.00E+00	1.54	6.61E+09	6.24E+08
Rn-222	-	2.28E-12	1.69E-09	0.00E+00	0.00E+00	0.00E+00	1.54	6.61E+09	6.62E+01
Th-230	F	3.41E-08	8.45E-10	1.19E-10	1.66E-10	2.30E-04	1.54	6.61E+09	9.19E-06
Th-234	S	3.08E-11	1.77E-08	3.39E-11	6.25E-11	2.30E-04	1.54	6.61E+09	1.05E+01
TI-206	-	0.00E+00	6.11E-09	0.00E+00	0.00E+00	2.00E-02	1.54	6.61E+09	8.67E+04
TI-210	-	0.00E+00	1.34E-05	0.00E+00	0.00E+00	2.00E-02	1.54	6.61E+09	2.80E+05
U-234	S	2.78E-08	2.53E-10	9.55E-11	1.48E-10	3.90E-04	1.54	6.61E+09	2.82E-06
U-238	S	2.36E-08	1.24E-10	8.66E-11	1.34E-10	3.90E-04	1.54	6.61E+09	1.55E-10

**Site-specific**Farmer Individual Risk Contributions for Soil - Secular Equilibrium

Isotope	Halflife (yr)	1000029 m² Soil Volume Area Correction Factor	0 cm Soil Volume Gamma Shielding Factor	Total Indoor GSF Soil Volume	Dry Soil-to-plant transfer factor (pCi/g-fresh plant per pCi/g-dry soil)	K <sub>d</sub> Distribution coefficient (L/kg)	Ingestion CDI (pCi)	Inhalation CDI (pCi)	External Exposure CDI (pCi)
Rn-218	1.11E-09	1.00E+00	1.00E+00	4.00E-01	0.00E+00	0.00E+00	4.37E+03	1.17E-01	3.84E+01
Rn-222	1.05E-02	1.00E+00	1.00E+00	4.00E-01	0.00E+00	0.00E+00	4.37E+03	1.17E-01	3.84E+01
Th-230	7.54E+04	1.00E+00	1.00E+00	4.00E-01	2.41E-03	2.00E+01	4.37E+03	1.17E-01	3.84E+01
Th-234	6.60E-02	1.00E+00	1.00E+00	4.00E-01	2.41E-03	2.00E+01	4.37E+03	1.17E-01	3.84E+01
TI-206	7.99E-06	1.00E+00	1.00E+00	4.00E-01	6.00E-01	1.50E+03	4.37E+03	1.17E-01	3.84E+01
TI-210	2.47E-06	1.00E+00	1.00E+00	4.00E-01	6.00E-01	1.50E+03	4.37E+03	1.17E-01	3.84E+01
U-234	2.46E+05	1.00E+00	1.00E+00	4.00E-01	7.13E-03	4.00E-01	4.37E+03	1.17E-01	3.84E+01
U-238	4.47E+09	1.00E+00	1.00E+00	4.00E-01	7.13E-03	4.00E-01	4.37E+03	1.17E-01	3.84E+01

**Site-specific**Farmer Individual Risk Contributions for Soil - Secular Equilibrium

Isotope	Produce Consumption CDI (pCi)	Beef CDI (pCi)	Ingestion Risk	Inhalation Risk	External Exposure Risk	Produce Consumption Risk	Beef Risk	Total Risk
Rn-218	-	0.00E+00	0.00E+00	0.00E+00	2.60E-14	-	0.00E+00	2.60E-14
Rn-222	-	0.00E+00	0.00E+00	2.68E-13	6.50E-08	-	0.00E+00	6.50E-08
Th-230	-	5.07E+03	7.25E-07	4.00E-09	3.25E-08	-	6.04E-07	1.37E-06
Th-234	-	5.07E+03	2.73E-07	3.61E-12	6.81E-07	-	1.72E-07	1.13E-06
TI-206	-	1.33E+06	0.00E+00	0.00E+00	3.14E-13	-	0.00E+00	3.14E-13
TI-210	-	1.33E+06	0.00E+00	0.00E+00	1.08E-07	-	0.00E+00	1.08E-07
U-234	-	8.73E+03	6.48E-07	3.27E-09	9.73E-09	-	8.34E-07	1.49E-06
U-238	-	8.73E+03	5.86E-07	2.78E-09	4.75E-09	-	7.56E-07	1.35E-06

# RESRAD OUTPUT DCGL CALCULATION (SEE PAGE 7)

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Intrisk: RESRAD Residential Land-Use Scenario (No Produce, No Radon)
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Part III: Intake Quantities and Health Risk Factors

Cancer Risk Slope Factors       2         Risk Slope and ETFG for the Ground Pathway       4         Amount of Intake Quantities and Excess Cancer Risks       5         Time= 0.000E+00       8         Time= 3.000E+00       11         Time= 1.000E+01       14         Time= 3.000E+01       17         Time= 1.000E+02       20         Time= 3.000E+03       26					
Amount of Intake Quantities and Excess Cancer Risks  Time= 0.000E+00	Cancer Risk Slo	pe Factors			2
Time= 0.000E+00 5 Time= 1.000E+00 8 Time= 3.000E+00 11 Time= 1.000E+01 14 Time= 3.000E+01 17 Time= 1.000E+02 20 Time= 3.000E+02 23	Risk Slope and	ETFG for the Gro	ound Pathway .		4
Time= 1.000E+00 8 Time= 3.000E+00 11 Time= 1.000E+01 14 Time= 3.000E+01 17 Time= 1.000E+02 20 Time= 3.000E+02 23	Amount of Intal	ke Quantities and	l Excess Cance	r Risks	
Time= 3.000E+00 11 Time= 1.000E+01 14 Time= 3.000E+01 17 Time= 1.000E+02 20 Time= 3.000E+02 23	Time= 0.00	)0E+00			5
Time= 1.000E+01 14 Time= 3.000E+01 17 Time= 1.000E+02 20 Time= 3.000E+02 23	Time= 1.00	00E+00			8
Time= 3.000E+01	Time= 3.00	)0E+00			11
Time= 1.000E+02	Time= 1.00	OE+01			14
Time= 3.000E+02	Time= 3.00	OE+01			17
	Time= 1.00	00E+02			20
Time= 1.000E+03	Time= 3.00	00E+02			23
	Time= 1.00	00E+03			26

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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### Cancer Risk Slope Factors Summary Table Risk Library: DCFPAK3.02 Morbidity

	  -	Current	Base	Parameter
Menu	Parameter	Value	Case*	Name
Sf-1	Ground external radiation slope factors, 1/yr per (pCi/g):		' 	
Sf-1	Ac-227+D	1.63E-06	1.98E-10	SLPF( 1,1)
Sf-1	Pa-231	1.27E-07	1.27E-07	SLPF( 2,1)
Sf-1	Pb-210+D	4.25E-09	1.48E-09	SLPF( 3,1)
Sf-1	Pb-210+D1	1.72E-08	1.48E-09	SLPF( 4,1)
Sf-1	Po-210	4.51E-11	4.51E-11	SLPF( 5,1)
Sf-1	Ra-226+D	8.37E-06	2.50E-08	SLPF( 6,1)
Sf-1	Th-230	8.45E-10	8.45E-10	SLPF( 8,1)
Sf-1	U-234	2.53E-10	2.53E-10	SLPF( 10,1)
Sf-1	U-235+D	5.76E-07	5.51E-07	SLPF( 12,1)
Sf-1	U-238	1.24E-10	1.24E-10	SLPF( 13,1)
Sf-1	U-238+D 	1.19E-07	1.24E-10	SLPF( 14,1)
Sf-2	Inhalation, slope factors, 1/(pCi):		! 	! 
Sf-2	Ac-227+D	2.13E-07	1.49E-07	SLPF( 1,2)
Sf-2	Pa-231	7.62E-08	7.62E-08	SLPF( 2,2)
Sf-2	Pb-210+D	1.63E-08	1.59E-08	SLPF( 3,2)
Sf-2	Pb-210+D1	1.63E-08	1.59E-08	SLPF( 4,2)
Sf-2	Po-210	1.45E-08	1.45E-08	SLPF( 5,2)
Sf-2	Ra-226+D	2.82E-08	2.81E-08	SLPF( 6,2)
Sf-2	Th-230	3.41E-08	3.41E-08	SLPF( 8,2)
Sf-2	U-234	2.78E-08	2.78E-08	SLPF( 10,2)
Sf-2	U-235+D	2.50E-08	2.50E-08	SLPF( 12,2)
Sf-2	U-238	2.36E-08	2.36E-08	SLPF( 13,2)
Sf-2	U-238+D	2.37E-08	2.36E-08	SLPF( 14,2)
Sf-3	   Food ingestion, slope factors, 1/(pCi):	 	! 	! 
Sf-3	Ac-227+D	6.54E-10	2.45E-10	SLPF( 1,3)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF( 2,3)
Sf-3	Pb-210+D	1.19E-09	1.18E-09	SLPF( 3,3)
Sf-3	Pb-210+D1	1.19E-09	1.18E-09	SLPF( 4,3)
Sf-3	Po-210	2.25E-09	2.25E-09	SLPF( 5,3)
Sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF( 6,3)
Sf-3	Th-230	1.19E-10	1.19E-10	SLPF( 8,3)
Sf-3	U-234	9.55E-11	9.55E-11	SLPF( 10,3)
Sf-3	U-235+D	9.76E-11	9.43E-11	SLPF( 12,3)
Sf-3	U-238	8.66E-11	8.66E-11	SLPF( 13,3)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF( 14,3)
Sf-3	   Water ingestion, slope factors, 1/(pCi):		 	! 
Sf-3	Ac-227+D	4.87E-10	2.01E-10	SLPF( 1,4)
Sf-3	Pa-231	1.72E-10	1.72E-10	SLPF( 2,4)
Sf-3	Pb-210+D	8.93E-10	8.84E-10	SLPF( 3,4)
Sf-3	Pb-210+D1	8.93E-10	8.84E-10	SLPF( 4,4)
Sf-3	Po-210	1.78E-09	1.78E-09	SLPF( 5,4)
Sf-3	Ra-226+D	3.85E-10	3.85E-10	SLPF( 6,4)
Sf-3	Th-230	9.14E-11	9.14E-11	SLPF( 8,4)
Sf-3	U-234	7.07E-11	7.07E-11	SLPF( 10,4)
Sf-3	U-235+D	7.17E-11	6.95E-11	SLPF( 12,4)
Sf-3	U-238	6.40E-11	6.40E-11	SLPF( 13,4)

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Cancer Risk Slope Factors Summary Table (continued)
Risk Library: DCFPAK3.02 Morbidity

		Current	Base	Parameter
Menu	Parameter	Value	Case*	Name
Sf-3	U-238+D	8.71E-11	6.40E-11	SLPF( 14,4)
Sf-3	   Soil ingestion, slope factors, 1/(pCi):	 	 	 
Sf-3	Ac-227+D	6.54E-10	2.45E-10	SLPF( 1,5)
Sf-3	Pa-231	2.26E-10	2.26E-10	SLPF( 2,5)
Sf-3	Pb-210+D	1.19E-09	1.18E-09	SLPF( 3,5)
sf-3	Pb-210+D1	1.19E-09	1.18E-09	SLPF( 4,5)
sf-3	Po-210	2.25E-09	2.25E-09	SLPF( 5,5)
sf-3	Ra-226+D	5.15E-10	5.14E-10	SLPF( 6,5)
sf-3	Th-230	1.19E-10	1.19E-10	SLPF( 8,5)
sf-3	U-234	9.55E-11	9.55E-11	SLPF( 10,5)
Sf-3	U-235+D	9.76E-11	9.43E-11	SLPF( 12,5)
sf-3	U-238	8.66E-11	8.66E-11	SLPF( 13,5)
Sf-3	U-238+D	1.21E-10	8.66E-11	SLPF( 14,5)
			1	
Sf-Rn	Radon Inhalation slope factors, 1/(pCi):		I	l
Sf-Rn	Rn-222	1.80E-12	1.80E-12	SLPFRN(1,1)
Sf-Rn	Po-218	3.70E-12	3.70E-12	SLPFRN(1,2)
Sf-Rn	Pb-214	6.20E-12	6.20E-12	SLPFRN(1,3)
Sf-Rn	Bi-214	1.50E-11	1.50E-11	SLPFRN(1,4)
			I	1
Sf-Rn	Radon K factors, (mrem/WLM):		I	I
Sf-Rn	Rn-222 Indoor	3.88E+02	3.88E+02	KFACTR(1,1)
Sf-Rn	Rn-222 Outdoor	3.88E+02	3.88E+02	KFACTR(1,2)

<sup>\*</sup>Base Case means Default.Lib w/o Associate Nuclide contributions.

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Nuclide Slope(i)\*

Risk Slope and Environmental Transport Factors for the Ground Pathway

ETFG(i,t) At Time in Years (dimensionless)

Rick Grope and Environmental Transport ractors for the Ground rachway

(i)	t=	= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	1.990E-10	3.137E-01	3.137E-01	3.137E-01	3.137E-01	3.137E-01	3.137E-01	3.137E-01	3.137E-01
At-218	2.740E-11	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01
At-219	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Bi-210	2.770E-09	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01
Bi-211	1.900E-07	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01
Bi-214	7.340E-06	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01	3.010E-01
Bi-215	1.080E-06	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01	3.029E-01
Fr-223	1.350E-07	3.042E-01	3.042E-01	3.042E-01	3.042E-01	3.042E-01	3.042E-01	3.042E-01	3.042E-01
Hg-206	4.830E-07	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01
Pa-231	1.270E-07	3.059E-01	3.059E-01	3.059E-01	3.059E-01	3.059E-01	3.059E-01	3.059E-01	3.059E-01
Pa-234	6.620E-06	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01
Pa-234m	9.060E-08	3.006E-01	3.006E-01	3.006E-01	3.006E-01	3.006E-01	3.006E-01	3.006E-01	3.006E-01
Pb-210	1.480E-09	3.321E-01	3.321E-01	3.321E-01	3.321E-01	3.321E-01	3.321E-01	3.321E-01	3.321E-01
Pb-211	2.910E-07	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01
Pb-214	9.940E-07	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01
Po-210	4.510E-11	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01
Po-211	3.760E-08	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01
Po-214	3.850E-10	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01
Po-215	7.480E-10	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01
Po-218	6.840E-15	3.090E-01	3.090E-01	3.090E-01	3.090E-01	3.090E-01	3.090E-01	3.090E-01	3.090E-01
Ra-223	4.550E-07	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01
Ra-226	2.500E-08	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01
Rn-218	3.390E-09	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01	2.986E-01
Rn-219	2.350E-07	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01	3.058E-01
Rn-222	1.690E-09	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01
Th-227	4.450E-07	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01
Th-230	8.450E-10	3.098E-01	3.098E-01	3.098E-01	3.098E-01	3.098E-01	3.098E-01	3.098E-01	3.098E-01
Th-231	2.490E-08	3.290E-01	3.290E-01	3.290E-01	3.290E-01	3.290E-01	3.290E-01	3.290E-01	3.290E-01
Th-234	1.780E-08	3.091E-01	3.091E-01	3.091E-01	3.091E-01	3.091E-01	3.091E-01	3.091E-01	3.091E-01
T1-206	6.110E-09	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01
T1-207	1.590E-08	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01	2.989E-01
T1-210	1.340E-05	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01	3.005E-01
U-234	2.530E-10	3.316E-01	3.316E-01	3.316E-01	3.316E-01	3.316E-01	3.316E-01	3.316E-01	3.316E-01
U-235	5.510E-07	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01	3.069E-01
U-238	1.240E-10	3.160E-01	3.160E-01	3.160E-01	3.160E-01	3.160E-01	3.160E-01	3.160E-01	3.160E-01

 $<sup>\</sup>star$  - Units are 1/yr per (pCi/g) at infinite depth and area. Multiplication by ETFG(i,t) converts to site conditions.

RESRAD-ONSITE, Version 7.2 T½ Limit = 30 days 06/10/2019 09:34 Page 5

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 0.000E+00 years

As per/yr at t= 0.000E/00 years

	Water Ind	ependent Pa	thways (Inh	alation w/o	radon)			— Total			
Radio- Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Total Ingestion*
Ac-227	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
Pa-231	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
Pb-210	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
Po-210	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
Ra-226	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
Th-230	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-234	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-235	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-238	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 0.000E+00 years

### Radionuclides

Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.		0.000E+00 0.000E+00						
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=0.000E+00 years

	Grou	Ground		Inhalation		nt	Meat	t	Mil	k	Soil	1
Radio- Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	1.178E-05	0.1370	7.986E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.853E-07	0.0056
Pa-231	9.676E-07	0.0112	2.995E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.758E-07	0.0020
Pb-210	3.379E-08	0.0004	6.541E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.442E-07	0.0110
Po-210	3.415E-10	0.0000	5.765E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.775E-06	0.0206
Ra-226	6.361E-05	0.7395	1.123E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.061E-07	0.0047
Th-230	6.807E-09	0.0001	1.398E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.683E-08	0.0011
U-234	2.090E-09	0.0000	1.093E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.435E-08	0.0009
U-235	4.416E-06	0.0513	9.830E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.599E-08	0.0009
U-238	8.952E-07	0.0104	9.303E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.387E-08	0.0011
Total	8.172E-05	0.9499	1.774E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.128E-06	0.0480

RESRAD-ONSITE, Version 7.2  $T_2$  Limit = 30 days 06/10/2019 09:34 Page 6

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=0.000E+00 years

### Water Dependent Pathways

D - 44 -	Wate	Water		Fish		nt	Meat	Ę	Mill	ζ.	All Path	nways**
Radio- Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	1.235E-05	0.1435								
Pa-231	0.000E+00	0.0000	1.173E-06	0.0136								
Pb-210	0.000E+00	0.0000	9.846E-07	0.0114								
Po-210	0.000E+00	0.0000	1.782E-06	0.0207								
Ra-226	0.000E+00	0.0000	6.403E-05	0.7443								
Th-230	0.000E+00	0.0000	1.176E-07	0.0014								
U-234	0.000E+00	0.0000	8.738E-08	0.0010								
U-235	0.000E+00	0.0000	4.502E-06	0.0523								
U-238	0.000E+00	0.0000	9.984E-07	0.0116								
Total	0.000E+00	0.0000	8.602E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 0.000E+00 years

### Radionuclides

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
		0.000E+00 0.000E+00					0.000E+00 0.000E+00	0.000E+00 0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=0.000E+00 years

Water Independent Pathways (Inhalation excludes radon)

	Grou	nd	Inhala	tion	Rado	on	Plant	t	Meat	t	Mill	k	Soil	L
Radio- Nuclide	risk	fract.												
Ac-227	8.016E-06	0.0932	5.434E-08	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.302E-07	0.0038
Pa-231	4.732E-06	0.0550	5.547E-08	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.309E-07	0.0038
Pb-210	2.349E-08	0.0003	8.411E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.854E-06	0.0216
Po-210	7.342E-12	0.0000	1.240E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.817E-08	0.0004
Ra-226	6.326E-05	0.7354	1.492E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.228E-06	0.0143
Th-230	3.674E-07	0.0043	1.405E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.024E-07	0.0012
U-234	2.119E-09	0.0000	1.094E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.436E-08	0.0009
U-235	4.417E-06	0.0514	9.843E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.607E-08	0.0009
U-238	8.952E-07	0.0104	9.304E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.387E-08	0.0011
Total	8.172E-05	0.9499	1.774E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.128E-06	0.0480

DCGL = Target Risk of 1E-04 ÷ Total Risk Across All Pathways of 8.6E-05 = 1.2 pCi/g U-238 and all progeny

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=0.000E+00 years

### Water Dependent Pathways

Radio-	Water	c	Fish	ı	Rado	on	Plant	t	Meat	=	Mil}	ς	All path	nways
Radio- Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	8.400E-06	0.0977										
Pa-231	0.000E+00	0.0000	5.119E-06	0.0595										
Pb-210	0.000E+00	0.0000	1.886E-06	0.0219										
Po-210	0.000E+00	0.0000	3.830E-08	0.0004										
Ra-226	0.000E+00	0.0000	6.450E-05	0.7499										
Th-230	0.000E+00	0.0000	4.838E-07	0.0056										
U-234	0.000E+00	0.0000	8.742E-08	0.0010										
U-235	0.000E+00	0.0000	4.503E-06	0.0524										
U-238	0.000E+00	0.0000	9.984E-07	0.0116										
Total	0.000E+00	0.0000	8.602E-05	1.0000										

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 1.000E+00 years

Water Independent Pathways (Inhalation w/o radon)

Water Dependent Pathways

Radio-											Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.565E-02	0.000E+00	0.000E+00	0.000E+00	3.102E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.102E+01
Pa-231	1.573E-02	0.000E+00	0.000E+00	0.000E+00	3.117E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.117E+01
Pb-210	1.575E-02	0.000E+00	0.000E+00	0.000E+00	3.122E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.122E+01
Po-210	1.565E-02	0.000E+00	0.000E+00	0.000E+00	3.101E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.101E+01
Ra-226	1.574E-02	0.000E+00	0.000E+00	0.000E+00	3.120E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.120E+01
Th-230	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-234	1.573E-02	0.000E+00	0.000E+00	0.000E+00	3.117E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.117E+01
U-235	1.573E-02	0.000E+00	0.000E+00	0.000E+00	3.117E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.117E+01
U-238	1.573E-02	0.000E+00	0.000E+00	0.000E+00	3.117E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.117E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 1.000E+00 years

### Radionuclides

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
		0.000E+00 0.000E+00						0.000E+00 0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+00 years

	Grou	nd	Inhalat	tion	Plan	nt	Meat		Mill	ζ.	Soil	L
Radio-												
Nuclide	risk	fract.										
Ac-227	1.170E-05	0.1365	7.934E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.821E-07	0.0056
Pa-231	9.644E-07	0.0112	2.985E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.752E-07	0.0020
Pb-210	3.373E-08	0.0004	6.529E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.425E-07	0.0110
Po-210	3.408E-10	0.0000	5.754E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.772E-06	0.0207
Ra-226	6.346E-05	0.7400	1.120E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.051E-07	0.0047
Th-230	6.807E-09	0.0001	1.398E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.683E-08	0.0011
U-234	2.083E-09	0.0000	1.090E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.411E-08	0.0009
U-235	4.402E-06	0.0513	9.798E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.574E-08	0.0009
U-238	8.922E-07	0.0104	9.272E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.356E-08	0.0011
Total	8.147E-05	0.9499	1.766E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.117E-06	0.0480

RESRAD-ONSITE, Version 7.2  $T^{1/2}$  Limit = 30 days 06/10/2019 09:34 Page

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 1.000E+00 years

### Water Dependent Pathways

	Wate	r	Fish	ı	Plan	nt	Meat	5	Mill	K	All Path	nways**
Radio-			-								-	
Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	1.227E-05	0.1430								
Pa-231	0.000E+00	0.0000	1.169E-06	0.0136								
Pb-210	0.000E+00	0.0000	9.827E-07	0.0115								
Po-210	0.000E+00	0.0000	1.778E-06	0.0207								
Ra-226	0.000E+00	0.0000	6.388E-05	0.7448								
Th-230	0.000E+00	0.0000	1.176E-07	0.0014								
U-234	0.000E+00	0.0000	8.709E-08	0.0010								
U-235	0.000E+00	0.0000	4.487E-06	0.0523								
U-238	0.000E+00	0.0000	9.950E-07	0.0116								
Total	0.000E+00	0.0000	8.576E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 1.000E+00 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.								
Total	0.000E+00							

Water-ind. == Water-independent Water-dep. == Water-dependent

RESRAD-ONSITE, Version 7.2 T\( \) Limit = 30 days 06/10/2019 09:34 Page 10

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 1.000E+00 years

### Water Independent Pathways (Inhalation excludes radon)

	Groun	nd	Inhala	tion	Rado	on	Plant	Ē	Meat	:	Mil	c	Soil	L
Radio-														
Nuclide	risk	fract.												
Ac-227	7.701E-06	0.0898	5.220E-08	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.172E-07	0.0037
Pa-231	4.966E-06	0.0579	5.697E-08	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.400E-07	0.0040
Pb-210	2.273E-08	0.0003	8.240E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.825E-06	0.0213
Po-210	1.159E-12	0.0000	1.957E-11	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.027E-09	0.0001
Ra-226	6.309E-05	0.7356	1.514E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.282E-06	0.0150
Th-230	3.947E-07	0.0046	1.406E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.029E-07	0.0012
U-234	2.115E-09	0.0000	1.090E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.412E-08	0.0009
U-235	4.403E-06	0.0513	9.812E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.583E-08	0.0009
U-238	8.922E-07	0.0104	9.273E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.356E-08	0.0011
Total	8.147E-05	0.9499	1.766E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.117E-06	0.0480

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+00 years

### Water Dependent Pathways

	Wate	<u>c</u>	Fish	h	Rado	on	Plant	t	Mea	Ē.	Mil	k	All path	nways
Radio- Nuclide	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.	risk	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.070E-06	0.0941
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.363E-06	0.0625
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.856E-06	0.0216
Po-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.047E-09	0.0001
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.438E-05	0.7507
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.117E-07	0.0060
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.713E-08	0.0010
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.488E-06	0.0523
	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.950E-07	0.0116
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.576E-05	1.0000

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 3.000E+00 years

Water Independent Pathways (Inhalation w/o radon)

Water Dependent Pathways

Radio-											Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.540E-02	0.000E+00	0.000E+00	0.000E+00	3.053E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.053E+01
Pa-231	1.562E-02	0.000E+00	0.000E+00	0.000E+00	3.096E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.096E+01
Pb-210	1.570E-02	0.000E+00	0.000E+00	0.000E+00	3.111E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.111E+01
Po-210	1.557E-02	0.000E+00	0.000E+00	0.000E+00	3.087E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.087E+01
Ra-226	1.567E-02	0.000E+00	0.000E+00	0.000E+00	3.105E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.105E+01
Th-230	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-234	1.562E-02	0.000E+00	0.000E+00	0.000E+00	3.096E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.096E+01
U-235	1.562E-02	0.000E+00	0.000E+00	0.000E+00	3.096E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.096E+01
U-238	1.562E-02	0.000E+00	0.000E+00	0.000E+00	3.096E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.096E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 3.000E+00 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.							0.000E+00 0.000E+00	
Total	0.000E+00	0.000E+00						

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t = 3.000E+00 years

	Grou	nd	Inhalat	tion	Plar	nt	Meat		Mill	ζ.	Soil	L
Radio-												
Nuclide	risk	fract.										
Ac-227	1.155E-05	0.1355	7.832E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.759E-07	0.0056
Pa-231	9.580E-07	0.0112	2.966E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.741E-07	0.0020
Pb-210	3.360E-08	0.0004	6.504E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.389E-07	0.0110
Po-210	3.395E-10	0.0000	5.732E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.765E-06	0.0207
Ra-226	6.316E-05	0.7409	1.115E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.032E-07	0.0047
Th-230	6.807E-09	0.0001	1.398E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.683E-08	0.0011
U-234	2.069E-09	0.0000	1.083E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.362E-08	0.0009
U-235	4.373E-06	0.0513	9.733E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.524E-08	0.0009
U-238	8.863E-07	0.0104	9.211E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.294E-08	0.0011
Total	8.098E-05	0.9499	1.751E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.096E-06	0.0480

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+00 years

### Water Dependent Pathways

	Wate	r	Fish	n	Pla	nt	Meat	5	Mil	k	All Path	nways**
Radio- Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	1.211E-05	0.1420								
Pa-231	0.000E+00	0.0000	1.162E-06	0.0136								
Pb-210	0.000E+00	0.0000	9.790E-07	0.0115								
Po-210	0.000E+00	0.0000	1.771E-06	0.0208								
Ra-226	0.000E+00	0.0000	6.358E-05	0.7458								
Th-230	0.000E+00	0.0000	1.176E-07	0.0014								
U-234	0.000E+00	0.0000	8.651E-08	0.0010								
U-235	0.000E+00	0.0000	4.458E-06	0.0523								
U-238	0.000E+00	0.0000	9.885E-07	0.0116								
Total	0.000E+00	0.0000	8.525E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 3.000E+00 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.								
Total	0.000E+00							

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 3.000E+00 years

### Water Independent Pathways (Inhalation excludes radon)

	Groun	nd	Inhala	tion	Rade	on	Plant	t	Meat	5	Mil	c	Soil	L
Radio-														
Nuclide	risk	fract.												
Ac-227	7.108E-06	0.0834	4.818E-08	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.928E-07	0.0034
Pa-231	5.403E-06	0.0634	5.978E-08	0.0007	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.571E-07	0.0042
Pb-210	2.129E-08	0.0002	7.734E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.714E-06	0.0201
Po-210	2.889E-14	0.0000	4.878E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.502E-10	0.0000
Ra-226	6.273E-05	0.7359	1.555E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.385E-06	0.0163
Th-230	4.492E-07	0.0053	1.407E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.041E-07	0.0012
U-234	2.109E-09	0.0000	1.083E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.363E-08	0.0009
U-235	4.374E-06	0.0513	9.749E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.534E-08	0.0009
U-238	8.863E-07	0.0104	9.212E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.294E-08	0.0011
Total	8.098E-05	0.9499	1.751E-07	0.0021	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.096E-06	0.0480

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+00 years

### Water Dependent Pathways

	Wate	r	Fis	n	Rado	on	Plant	t	Mea	t	Mil	k	All path	nways
Radio-														
Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	7.449E-06	0.0874										
Pa-231	0.000E+00	0.0000	5.820E-06	0.0683										
Pb-210	0.000E+00	0.0000	1.743E-06	0.0205										
Po-210	0.000E+00	0.0000	1.507E-10	0.0000										
Ra-226	0.000E+00	0.0000	6.413E-05	0.7523										
Th-230	0.000E+00	0.0000	5.674E-07	0.0067										
U-234	0.000E+00	0.0000	8.656E-08	0.0010										
U-235	0.000E+00	0.0000	4.459E-06	0.0523										
U-238	0.000E+00	0.0000	9.885E-07	0.0116										
Total	0.000E+00	0.0000	8.525E-05	1.0000										

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U-238

Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 1.000E+01 years

Water Independent Pathways (Inhalation w/o radon) Water Dependent Pathways Radio-Total Milk Fish Nuclide Inhalation Plant Soil Plant Milk Ingestion\* Meat Water Meat Ac-227 1.463E-02 0.000E+00 0.000E+00 0.000E+00 2.900E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 2.900E+01 Pa-231 1.526E-02 0.000E+00 0.000E+00 0.000E+00 3.025E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.025E+01 Pb-210 1.550E-02 0.000E+00 0.000E+00 0.000E+00 3.073E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.073E+01 Po-210 1.538E-02 0.000E+00 0.000E+00 0.000E+00 3.048E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.048E+01 Ra-226 1.541E-02 0.000E+00 0.000E+00 0.000E+00 3.054E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.054E+01 Th-230 1.578E-02 0.000E+00 0.000E+00 0.000E+00 3.127E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.127E+01 1.526E-02 0.000E+00 0.000E+00 0.000E+00 3.025E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.025E+01 U-234 U-235 1.526E-02 0.000E+00 0.000E+00 0.000E+00 3.025E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 3.025E+01

 $1.526E-02 \quad 0.000E+00 \quad 0.000E+00 \quad 0.000E+00 \quad 0.000E+00 \quad 3.025E+01 \quad 0.000E+00 \quad 0.000E+00 \quad 0.000E+00 \quad 0.000E+00 \quad 0.000E+00 \quad 3.025E+01 \quad 0.000E+00 \quad 0.00$ 

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 1.000E+01 years

Radionuclides

# Radon Pathway Rn-222 Po-218 Pb-214 Bi-214 Rn-220 Po-216 Pb-212 Bi-212 Water-ind. 0.000E+00 0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+01 years

	Grou	nd	Inhala	tion	Plan	nt	Meat	5	Mil	k	Soil	L
Radio-												
Nuclide	risk	fract.										
Ac-227	1.108E-05	0.1326	7.509E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.563E-07	0.0055
Pa-231	9.360E-07	0.0112	2.897E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.701E-07	0.0020
Pb-210	3.314E-08	0.0004	6.415E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.260E-07	0.0111
Po-210	3.349E-10	0.0000	5.653E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.741E-06	0.0208
Ra-226	6.213E-05	0.7439	1.097E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.966E-07	0.0047
Th-230	6.806E-09	0.0001	1.398E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.683E-08	0.0012
U-234	2.021E-09	0.0000	1.058E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.193E-08	0.0009
U-235	4.272E-06	0.0512	9.509E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.351E-08	0.0009
U-238	8.660E-07	0.0104	9.000E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.081E-08	0.0011
Total	7.933E-05	0.9498	1.702E-07	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.023E-06	0.0482

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+01 years

### Water Dependent Pathways

Radio-	Wate:	r	Fish	ı	Plan	nt	Meat	E	Mill	ς	All Path	nways**
Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	1.161E-05	0.1390								
Pa-231	0.000E+00	0.0000	1.135E-06	0.0136								
Pb-210	0.000E+00	0.0000	9.656E-07	0.0116								
Po-210	0.000E+00	0.0000	1.747E-06	0.0209								
Ra-226	0.000E+00	0.0000	6.254E-05	0.7488								
Th-230	0.000E+00	0.0000	1.176E-07	0.0014								
U-234	0.000E+00	0.0000	8.452E-08	0.0010								
U-235	0.000E+00	0.0000	4.355E-06	0.0521								
U-238	0.000E+00	0.0000	9.658E-07	0.0116								
Total	0.000E+00	0.0000	8.352E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 1.000E+01 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.		0.000E+00 0.000E+00						
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

	Groun	nd	Inhala	tion	Rado	on	Plan	t	Meat	5	Mil	ς	Soil	L
Radio- Nuclide	risk	fract.												
Ac-227	5.369E-06	0.0643	3.639E-08	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.212E-07	0.0026
Pa-231	6.642E-06	0.0795	6.764E-08	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.051E-07	0.0049
Pb-210	1.691E-08	0.0002	6.144E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.362E-06	0.0163
Po-210	7.065E-20	0.0000	1.193E-18	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.673E-16	0.0000
Ra-226	6.152E-05	0.7366	1.674E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.690E-06	0.0202
Th-230	6.376E-07	0.0076	1.412E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.088E-07	0.0013
U-234	2.095E-09	0.0000	1.058E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.194E-08	0.0009
U-235	4.274E-06	0.0512	9.535E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.366E-08	0.0009
U-238	8.660E-07	0.0104	9.000E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.081E-08	0.0011
Total	7.933E-05	0.9498	1.702E-07	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.023E-06	0.0482

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+01 years

### Water Dependent Pathways

	Wate	r	Fish	h	Rado	on	Plant	5	Meat	t	Mill	k	All path	nways
Radio-														
Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	5.626E-06	0.0674										
Pa-231	0.000E+00	0.0000	7.115E-06	0.0852										
Pb-210	0.000E+00	0.0000	1.385E-06	0.0166										
Po-210	0.000E+00	0.0000	3.686E-16	0.0000										
Ra-226	0.000E+00	0.0000	6.322E-05	0.7570										
Th-230	0.000E+00	0.0000	7.605E-07	0.0091										
U-234	0.000E+00	0.0000	8.462E-08	0.0010										
U-235	0.000E+00	0.0000	4.358E-06	0.0522										
U-238	0.000E+00	0.0000	9.658E-07	0.0116										
Total	0.000E+00	0.0000	8.352E-05	1.0000										

<sup>\*\*\*</sup>CNRSI(i,p,t) includes contribution from decay daughter radionuclides

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 3.000E+01 years

Water Independent Pathways (Inhalation w/o radon)

Water Dependent Pathways

Radio-											Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	1.300E-02	0.000E+00	0.000E+00	0.000E+00	2.577E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.577E+01
Pa-231	1.428E-02	0.000E+00	0.000E+00	0.000E+00	2.831E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.831E+01
Pb-210	1.490E-02	0.000E+00	0.000E+00	0.000E+00	2.953E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.953E+01
Po-210	1.479E-02	0.000E+00	0.000E+00	0.000E+00	2.930E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.930E+01
Ra-226	1.470E-02	0.000E+00	0.000E+00	0.000E+00	2.914E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.914E+01
Th-230	1.578E-02	0.000E+00	0.000E+00	0.000E+00	3.127E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.127E+01
U-234	1.428E-02	0.000E+00	0.000E+00	0.000E+00	2.831E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.831E+01
U-235	1.428E-02	0.000E+00	0.000E+00	0.000E+00	2.831E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.831E+01
U-238	1.428E-02	0.000E+00	0.000E+00	0.000E+00	2.831E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.831E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 3.000E+01 years

### Radionuclides

Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.		0.000E+00 0.000E+00						
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+01 years

	Grou	nd	Inhala	tion	Pla	nt	Meat	t	Mil	k	Soil	1
Radio- Nuclide	risk	fract.										
 Ac-227	1.002E-05	0.1268	6.789E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.126E-07	0.0052
Pa-231	8.759E-07	0.0111	2.711E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.592E-07	0.0020
Pb-210	3.178E-08	0.0004	6.152E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.881E-07	0.0112
Po-210	3.212E-10	0.0000	5.422E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.670E-06	0.0211
Ra-226	5.929E-05	0.7504	1.047E-08	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.785E-07	0.0048
Th-230	6.806E-09	0.0001	1.397E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.682E-08	0.0012
U-234	1.892E-09	0.0000	9.898E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.731E-08	0.0009
U-235	3.998E-06	0.0506	8.899E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.879E-08	0.0009
U-238	8.103E-07	0.0103	8.422E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.497E-08	0.0011
Total	7.503E-05	0.9496	1.582E-07	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.826E-06	0.0484

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 3.000E+01 years

### Water Dependent Pathways

	Wate	r	Fish	ı	Plan	nt	Meat	5	Mil	k	All Path	nways**
Radio- Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	1.050E-05	0.1328								
Pa-231	0.000E+00	0.0000	1.062E-06	0.0134								
Pb-210	0.000E+00	0.0000	9.260E-07	0.0117								
Po-210	0.000E+00	0.0000	1.676E-06	0.0212								
Ra-226	0.000E+00	0.0000	5.968E-05	0.7553								
Th-230	0.000E+00	0.0000	1.176E-07	0.0015								
U-234	0.000E+00	0.0000	7.910E-08	0.0010								
U-235	0.000E+00	0.0000	4.075E-06	0.0516								
U-238	0.000E+00	0.0000	9.037E-07	0.0114								
Total	0.000E+00	0.0000	7.902E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 3.000E+01 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
		0.000E+00 0.000E+00						0.000E+00 0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

RESRAD-ONSITE, Version 7.2 T\( \) Limit = 30 days 06/10/2019 09:34 Page 19

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 3.000E+01 years

Water Independent Pathways (Inhalation excludes radon)

	Groun	nd	Inhala	tion	Rado	on	Plant	t	Meat	=	Mil	c	Soil	L
Radio-														
Nuclide	risk	fract.												
Ac-227	2.409E-06	0.0305	1.633E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.921E-08	0.0013
Pa-231	8.478E-06	0.1073	7.862E-08	0.0010	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.722E-07	0.0060
Pb-210	8.760E-09	0.0001	3.183E-09	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.056E-07	0.0089
Po-210	0.000E+00	0.0000												
Ra-226	5.817E-05	0.7361	1.856E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.202E-06	0.0279
Th-230	1.156E-06	0.0146	1.427E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.259E-07	0.0016
U-234	2.121E-09	0.0000	9.902E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.734E-08	0.0009
U-235	4.003E-06	0.0507	8.953E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.912E-08	0.0009
U-238	8.103E-07	0.0103	8.423E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.498E-08	0.0011
Total	7.503E-05	0.9496	1.582E-07	0.0020	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.826E-06	0.0484

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+01 years

### Water Dependent Pathways

	Water	r	Fis	n	Rado	on	Plant	t	Mea	t	Mil	k	All path	nways
Radio-														
Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	2.524E-06	0.0319										
Pa-231	0.000E+00	0.0000	9.028E-06	0.1143										
Pb-210	0.000E+00	0.0000	7.175E-07	0.0091										
Po-210	0.000E+00	0.0000												
Ra-226	0.000E+00	0.0000	6.039E-05	0.7642										
Th-230	0.000E+00	0.0000	1.296E-06	0.0164										
U-234	0.000E+00	0.0000	7.936E-08	0.0010										
U-235	0.000E+00	0.0000	4.081E-06	0.0516										
U-238	0.000E+00	0.0000	9.037E-07	0.0114										
Total	0.000E+00	0.0000	7.902E-05	1.0000										

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 1.000E+02 years

Water Independent Pathways (Inhalation w/o radon)

Water Dependent Pathways

Radio-											Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	9.843E-03	0.000E+00	0.000E+00	0.000E+00	1.951E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.951E+01
Pa-231	1.132E-02	0.000E+00	0.000E+00	0.000E+00	2.244E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.244E+01
Pb-210	1.276E-02	0.000E+00	0.000E+00	0.000E+00	2.529E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.529E+01
Po-210	1.266E-02	0.000E+00	0.000E+00	0.000E+00	2.509E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.509E+01
Ra-226	1.251E-02	0.000E+00	0.000E+00	0.000E+00	2.480E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.480E+01
Th-230	1.577E-02	0.000E+00	0.000E+00	0.000E+00	3.126E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.126E+01
U-234	1.132E-02	0.000E+00	0.000E+00	0.000E+00	2.244E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.244E+01
U-235	1.132E-02	0.000E+00	0.000E+00	0.000E+00	2.244E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.244E+01
U-238	1.132E-02	0.000E+00	0.000E+00	0.000E+00	2.244E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	2.244E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 1.000E+02 years

### Radionuclides

Radon -								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.		0.000E+00 0.000E+00						0.000E+00 0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+02 years

	Grou	nd	Inhala	cion	Plan	nt	Meat	Ē	Mil	k	Soil	1
Radio- Nuclide	risk	fract.										
Ac-227	7.703E-06	0.1165	5.221E-08	0.0008	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.173E-07	0.0048
Pa-231	6.943E-07	0.0105	2.149E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.262E-07	0.0019
Pb-210	2.717E-08	0.0004	5.259E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.592E-07	0.0115
Po-210	2.746E-10	0.0000	4.636E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.428E-06	0.0216
Ra-226	5.052E-05	0.7641	8.918E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.225E-07	0.0049
Th-230	6.804E-09	0.0001	1.397E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.679E-08	0.0015
U-234	1.499E-09	0.0000	7.846E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.335E-08	0.0008
U-235	3.169E-06	0.0479	7.054E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.453E-08	0.0008
U-238	6.423E-07	0.0097	6.676E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.736E-08	0.0010
Total	6.276E-05	0.9493	1.281E-07	0.0019	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.225E-06	0.0488

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+02 years

### Water Dependent Pathways

Radio	Wate	Water		ı	Plan	nt	Meat	5	Mil	k	All Path	nways**
Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	8.072E-06	0.1221								
Pa-231	0.000E+00	0.0000	8.420E-07	0.0127								
Pb-210	0.000E+00	0.0000	7.916E-07	0.0120								
Po-210	0.000E+00	0.0000	1.432E-06	0.0217								
Ra-226	0.000E+00	0.0000	5.085E-05	0.7691								
Th-230	0.000E+00	0.0000	1.176E-07	0.0018								
U-234	0.000E+00	0.0000	6.270E-08	0.0009								
U-235	0.000E+00	0.0000	3.231E-06	0.0489								
U-238	0.000E+00	0.0000	7.164E-07	0.0108								
Total	0.000E+00	0.0000	6.612E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 1.000E+02 years

### Radionuclides

Radon Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
		0.000E+00 0.000E+00					0.000E+00 0.000E+00	0.000E+00 0.000E+00
Total	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+02 years

### Water Independent Pathways (Inhalation excludes radon)

	Grou	nd	Inhala	tion	Rado	on	Plan	t	Meat	t	Mil	¢	Soil	L
Radio- Nuclide	risk	fract.												
Ac-227	1.456E-07	0.0022	9.871E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.999E-09	0.0001
Pa-231	8.236E-06	0.1246	7.257E-08	0.0011	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.366E-07	0.0066
Pb-210	8.765E-10	0.0000	3.185E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.060E-08	0.0011
Po-210	0.000E+00	0.0000												
Ra-226	4.780E-05	0.7229	1.763E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.337E-06	0.0354
Th-230	2.756E-06	0.0417	1.482E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.979E-07	0.0030
U-234	2.837E-09	0.0000	7.856E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.346E-08	0.0008
U-235	3.185E-06	0.0482	7.200E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.540E-08	0.0008
U-238	6.423E-07	0.0097	6.678E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.737E-08	0.0010
Total	6.276E-05	0.9493	1.281E-07	0.0019	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.225E-06	0.0488

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+02 years

### Water Dependent Pathways

	Wate	r	Fis	n	Rado	on	Plant	t	Mea	t	Mill	k	All path	nways
Radio-														
Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	1.526E-07	0.0023										
Pa-231	0.000E+00	0.0000	8.745E-06	0.1323										
Pb-210	0.000E+00	0.0000	7.179E-08	0.0011										
Po-210	0.000E+00	0.0000												
Ra-226	0.000E+00	0.0000	5.015E-05	0.7585										
Th-230	0.000E+00	0.0000	2.968E-06	0.0449										
U-234	0.000E+00	0.0000	6.415E-08	0.0010										
U-235	0.000E+00	0.0000	3.247E-06	0.0491										
U-238	0.000E+00	0.0000	7.164E-07	0.0108										
Total	0.000E+00	0.0000	6.612E-05	1.0000										

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 3.000E+02 years

Water Independent Pathways (Inhalation w/o radon)

Water Dependent Pathways

Radio-											Total
Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Ingestion*
Ac-227	5.048E-03	0.000E+00	0.000E+00	0.000E+00	1.001E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.001E+01
Pa-231	5.829E-03	0.000E+00	0.000E+00	0.000E+00	1.155E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.155E+01
Pb-210	8.278E-03	0.000E+00	0.000E+00	0.000E+00	1.641E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.641E+01
Po-210	8.214E-03	0.000E+00	0.000E+00	0.000E+00	1.628E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.628E+01
Ra-226	8.182E-03	0.000E+00	0.000E+00	0.000E+00	1.622E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.622E+01
Th-230	1.575E-02	0.000E+00	0.000E+00	0.000E+00	3.121E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.121E+01
U-234	5.829E-03	0.000E+00	0.000E+00	0.000E+00	1.155E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.155E+01
U-235	5.829E-03	0.000E+00	0.000E+00	0.000E+00	1.155E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.155E+01
U-238	5.829E-03	0.000E+00	0.000E+00	0.000E+00	1.155E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.155E+01

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 3.000E+02 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.		0.000E+00						
water-dep.								
Total	0.000E+00							

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+02 years

Radio-	Grou	nd	Inhalat	tion	Plan	nt	Meat	5	Mill	ζ.	Soil	L
Nuclide	risk	fract.										
Ac-227	3.956E-06	0.0951	2.682E-08	0.0006	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.630E-07	0.0039
Pa-231	3.575E-07	0.0086	1.107E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.495E-08	0.0016
Pb-210	1.768E-08	0.0004	3.423E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.942E-07	0.0119
Po-210	1.787E-10	0.0000	3.017E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.291E-07	0.0223
Ra-226	3.316E-05	0.7974	5.853E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.117E-07	0.0051
Th-230	6.794E-09	0.0002	1.395E-08	0.0003	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.665E-08	0.0023
U-234	7.720E-10	0.0000	4.040E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.747E-08	0.0007
U-235	1.632E-06	0.0392	3.632E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.808E-08	0.0007
U-238	3.307E-07	0.0080	3.437E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.468E-08	0.0008
Total	3.946E-05	0.9489	7.523E-08	0.0018	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.050E-06	0.0493

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+02 years

### Water Dependent Pathways

	Wate	r	Fish	ı	Plan	nt	Meat	3	Mil	k	All Path	nways**
Radio- Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	4.146E-06	0.0997								
Pa-231	0.000E+00	0.0000	4.335E-07	0.0104								
Pb-210	0.000E+00	0.0000	5.153E-07	0.0124								
Po-210	0.000E+00	0.0000	9.323E-07	0.0224								
Ra-226	0.000E+00	0.0000	3.338E-05	0.8026								
Th-230	0.000E+00	0.0000	1.174E-07	0.0028								
U-234	0.000E+00	0.0000	3.228E-08	0.0008								
U-235	0.000E+00	0.0000	1.663E-06	0.0400								
U-238	0.000E+00	0.0000	3.688E-07	0.0089								
Total	0.000E+00	0.0000	4.159E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 3.000E+02 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.								
Total	0.000E+00							

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

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Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 3.000E+02 years

### Water Independent Pathways (Inhalation excludes radon)

Radio	Grou	nd	Inhala	tion	Rado	on	Plant	t	Meat	5	Mil	k	Soil	L
Radio- Nuclide	risk	fract.												
Ac-227	4.806E-11	0.0000	3.258E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.980E-12	0.0000
Pa-231	4.287E-06	0.1031	3.765E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.265E-07	0.0054
Pb-210	1.220E-12	0.0000	4.432E-13	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.826E-11	0.0000
Po-210	0.000E+00	0.0000												
Ra-226	2.726E-05	0.6556	1.024E-08	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.375E-06	0.0331
Th-230	5.914E-06	0.1422	1.597E-08	0.0004	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.561E-07	0.0086
U-234	7.714E-09	0.0002	4.063E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.790E-08	0.0007
U-235	1.658E-06	0.0399	3.866E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.949E-08	0.0007
U-238	3.307E-07	0.0080	3.441E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.470E-08	0.0008
Total	3.946E-05	0.9489	7.523E-08	0.0018	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.050E-06	0.0493

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=3.000E+02 years

### Water Dependent Pathways

	Wate	r	Fis	n	Rado	on	Plant	t	Mea	t	Mill	k	All path	nways
Radio-														
Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	5.037E-11	0.0000										
Pa-231	0.000E+00	0.0000	4.551E-06	0.1094										
Pb-210	0.000E+00	0.0000	9.992E-11	0.0000										
Po-210	0.000E+00	0.0000												
Ra-226	0.000E+00	0.0000	2.865E-05	0.6889										
Th-230	0.000E+00	0.0000	6.286E-06	0.1512										
U-234	0.000E+00	0.0000	3.968E-08	0.0010										
U-235	0.000E+00	0.0000	1.691E-06	0.0407										
U-238	0.000E+00	0.0000	3.689E-07	0.0089										
Total	0.000E+00	0.0000	4.159E-05	1.0000										

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Amount of Intake Quantities QINT(i,p,t) for Individual Radionuclides (i) and Pathways (p) As pCi/yr at t= 1.000E+03 years

_ ,,	Water Ind	ependent Pa	thways (Inh	alation w/o	radon)		Water	Dependent	Pathways		
Radio- Nuclide	Inhalation	Plant	Meat	Milk	Soil	Water	Fish	Plant	Meat	Milk	Total Ingestion*
Ac-227	4.944E-04	0.000E+00	0.000E+00	0.000E+00	9.799E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.799E-01
Pa-231	5.709E-04	0.000E+00	0.000E+00	0.000E+00	1.132E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.132E+00
Pb-210	3.136E-03	0.000E+00	0.000E+00	0.000E+00	6.215E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.215E+00
Po-210	3.110E-03	0.000E+00	0.000E+00	0.000E+00	6.163E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.163E+00
Ra-226	3.227E-03	0.000E+00	0.000E+00	0.000E+00	6.396E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.396E+00
Th-230	1.563E-02	0.000E+00	0.000E+00	0.000E+00	3.098E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.098E+01
U-234	5.709E-04	0.000E+00	0.000E+00	0.000E+00	1.132E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.132E+00
U-235	5.709E-04	0.000E+00	0.000E+00	0.000E+00	1.132E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.132E+00
U-238	5.709E-04	0.000E+00	0.000E+00	0.000E+00	1.132E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.132E+00

<sup>\*</sup> Sum of all ingestion pathways, i.e. water independent plant, meat, milk, soil and water-dependent water, fish, plant, meat, milk pathways

Amount of Intake Quantities QINT9(irn,i,t) and QINT9W(irn,i,t) for Inhalation of Radon and its Decay Products as pCi/yr at t= 1.000E+03 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind.	0.000E+00							
Water-dep.	0.000E+00							
Total	0.000E+00							

Water-ind. == Water-independent Water-dep. == Water-dependent

Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+03 years

Radio-	Grou	nd	Inhala	tion	Plan	nt	Meat	Ē	Mill	k	Soil	L
Nuclide	risk	fract.										
Ac-227	3.874E-07	0.0263	2.626E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.596E-08	0.0011
Pa-231	3.501E-08	0.0024	1.084E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.362E-09	0.0004
Pb-210	6.810E-09	0.0005	1.318E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.903E-07	0.0129
Po-210	6.877E-11	0.0000	1.161E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.575E-07	0.0243
Ra-226	1.329E-05	0.9040	2.347E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.486E-08	0.0058
Th-230	6.743E-09	0.0005	1.385E-08	0.0009	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.593E-08	0.0065
U-234	7.561E-11	0.0000	3.956E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.690E-09	0.0002
U-235	1.598E-07	0.0109	3.557E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.750E-09	0.0002
U-238	3.239E-08	0.0022	3.366E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.397E-09	0.0002
Total	1.392E-05	0.9467	2.347E-08	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.598E-07	0.0517

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Excess Cancer Risks CNRS(i,p,t) for Individual Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+03 years

### Water Dependent Pathways

	Wate	r	Fish	ı	Plan	nt	Meat		Mill	ζ.	All Path	nways**
Radio-			-		-						-	
Nuclide	risk	fract.										
Ac-227	0.000E+00	0.0000	4.060E-07	0.0276								
Pa-231	0.000E+00	0.0000	4.246E-08	0.0029								
Pb-210	0.000E+00	0.0000	1.984E-07	0.0135								
Po-210	0.000E+00	0.0000	3.588E-07	0.0244								
Ra-226	0.000E+00	0.0000	1.338E-05	0.9099								
Th-230	0.000E+00	0.0000	1.165E-07	0.0079								
U-234	0.000E+00	0.0000	3.162E-09	0.0002								
U-235	0.000E+00	0.0000	1.629E-07	0.0111								
U-238	0.000E+00	0.0000	3.612E-08	0.0025								
Total	0.000E+00	0.0000	1.471E-05	1.0000								

<sup>\*\*</sup> Sum of water independent ground, inhalation, plant, meat, milk, soil and water dependent water, fish, plant, meat, milk pathways

Excess Cancer Risks CNRS9(irn,i,t) and CNRS9W(irn,i,t) for Inhalation of Radon and its Decay Products at t= 1.000E+03 years

### Radionuclides

Radon								
Pathway	Rn-222	Po-218	Pb-214	Bi-214	Rn-220	Po-216	Pb-212	Bi-212
Water-ind. Water-dep.								
Total	0.000E+00							

 ${\tt Water-ind.} \ == \ {\tt Water-independent} \qquad {\tt Water-dep.} \ == \ {\tt Water-dependent}$ 

Intrisk : RESRAD Residential Land-Use Scenario (No Produce, No Radon)

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Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t= 1.000E+03 years

Water Independent Pathways (Inhalation excludes radon)

	Grou	nd	Inhala	tion	Rado	on	Plant	5	Meat		Mil	ς	Soil	L
Radio-			-										-	
Nuclide	risk	fract.												
Ac-227	3.138E-23	0.0000	2.127E-25	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.293E-24	0.0000
Pa-231	4.137E-07	0.0281	3.633E-09	0.0002	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.186E-08	0.0015
Pb-210	1.227E-22	0.0000	4.457E-23	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.881E-21	0.0000
Po-210	0.000E+00	0.0000												
Ra-226	3.822E-06	0.2599	1.436E-09	0.0001	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.928E-07	0.0131
Th-230	9.463E-06	0.6435	1.719E-08	0.0012	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.346E-07	0.0364
U-234	2.273E-08	0.0015	4.396E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.980E-09	0.0003
U-235	1.685E-07	0.0115	4.329E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.214E-09	0.0002
U-238	3.241E-08	0.0022	3.378E-10	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.405E-09	0.0002
Total	1.392E-05	0.9467	2.347E-08	0.0016	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.598E-07	0.0517

Total Excess Cancer Risk CNRS(i,p,t)\*\*\* for Initially Existent Radionuclides (i) and Pathways (p) and Fraction of Total Risk at t=1.000E+03 years

### Water Dependent Pathways

	Wate	r	Fis	n	Rado	on	Plant	t	Mea	t	Mil	k	All path	nways
Radio- Nuclide	risk	fract.												
Ac-227	0.000E+00	0.0000	3.289E-23	0.0000										
Pa-231	0.000E+00	0.0000	4.392E-07	0.0299										
Pb-210	0.000E+00	0.0000	1.005E-20	0.0000										
Po-210	0.000E+00	0.0000												
Ra-226	0.000E+00	0.0000	4.016E-06	0.2731										
Th-230	0.000E+00	0.0000	1.001E-05	0.6810										
U-234	0.000E+00	0.0000	2.715E-08	0.0018										
U-235	0.000E+00	0.0000	1.722E-07	0.0117										
	0.000E+00	0.0000	3.615E-08	0.0025										
Total	0.000E+00	0.0000	1.471E-05	1.0000										



### Table I-1

### **Summary of Alternative Costs**

### Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Source: WESTON, 2020

			C	OST	DURATION (MONTHS)			
ALTERNATIVE	DESCRIPTION	CAPITAL COST (2020)	ANNUA First 12 Years	AL COST To Year 99	NET PRESENT VALUE	PLANNING	CONSTRUCTION	TOTAL
1	No Further Action	\$ -	\$ 15,000	\$ 10,000.00	\$ 262,000			
2	0	\$ 50,640,000	\$ 35,000	\$ -	\$ 50,918,000	8.0	12.0	20.0
3	0	\$ 13,393,000	\$ 27,000	\$ 16,000	\$ 13,835,000	12.0	12.0	24.0

### **Estimate Notes:**

Detailed personnel and equipment rates, quantities, and cost adjustment factors are provided in Tables I-5 thru I-7.

Equipment rates are based on rental rates obtained from Gordian (RS Means Heavy Construction Cost Data, 34th Annual Edition, 2020. Includes operator labor rates provided by EPA.

Production rates are obtained from Gordian (RS Means) Heavy Construction Cost Data, 34th Annual Edition, 2020.

The average density of all wastes were assumed to be 1.3 tons per cubic yard. Loose cubic yards assumed a 20% swell factor.

Craft labor costs assume a 10-hour work day and 5 day work week.

Labor was adjusted with a factor based on the Gallup, New Mexico city cost index for Site and Infrastructure, Demolition (RSMeans, page 635).

Materials were adjusted with a factor based on the Gallup, New Mexico city cost index for Site and Infrastructure, Demolition (RSMeans, page 635).

Equipment factor is based on the Gallup, New Mexico city cost index for Contractor Equipment (RSMeans, page 635).

Mobilization costs include transportation of equipment and personnel (e.g. heavy equipment, office trailers, and additional supplies/equipment) and limited a 5% of total construction

Mileage is estimated to be 106 miles one way from Albuquerque, NM to the field site

Per diem rates are based on the maximum Federal 2020 CONUS Per Diem Rates.

Costs for low level radiological waste disposal were obtained from quotes from vendors in December 2019.

Present Value Subtotal for PRSC costs assume a discount rate of 7.0%.

Present value of post removal site control (PRSC) costs assume quarterly SWPPP insepctions and an annual general inspection and report for the first 12 years. Costs also assume minor fencing, revegetation, and water system repairs during each inspection.

Net present value was calcuated as follows:

NPV = Capital Cost + Annual Cost (Year 0 to 12) \* P/A + Annual Cost (Years 12-99). Adjustments for future value at year 12 not included.

### Net Present Value (NPV)

Real Discount Rate, i =	7.0%
Life cycle 1 (years), n	12
Uniform Series Present Worth Factor (P/A) =	7.94
Life cycle 2 (years) to year 99, n	87
Uniform Series Present Worth Factor (P/A) =	14.25



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# Table I-2 Alternative 2 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

						Duration
Item Description	Quantity	Unit	Unit Cost	Extension	Item Total	(work days)
CAPITAL COSTS:						
1 Engineering Design						168
Project Manager	134	HR	\$201	\$27,048		
Project Engineer	538	HR	\$184	\$98,918		
Design Engineer	1,075	HR	\$115	\$123,648		
CAD/GIS Operator	1,075	HR	\$98	\$105,101		
Admin	134	HR	\$19	\$2,520		
Expenses	1	LS	\$5,000	\$5,000	42.52.22	
Subtotal Engineering Costs		1.7%	(excl disposal)		\$362,235	1.00
2 Planning Documents	124	IID	6201	627.040		168
Project Manager	134	HR	\$201	\$27,048		
Project Engineer	1,075	HR	\$184	\$197,837		
CAD/GIS Operator	323	HR	\$98	\$31,530		
Admin	67	HR	\$19	\$1,260		
Expenses	1	LS	\$1,000	\$1,000	#250 <b>5</b> 75	
Subtotal Planning Documents					\$258,675	160
3 Resource Surveys  Geotechnical Testing and Report	2	EA	\$25,000	\$50,000		168
Geotechnical Testing and Report Pre-Project Aerial LIDAR Survey	22	AC	\$25,000	\$3,888		
Pre-Project Aerial LIDAR Survey Post-Project Aerial LIDAR Survey	22	AC AC	\$180 \$180	\$3,888		
Subtotal Resource Surveys	22	AC	\$100_	\$3,000	\$57,776	
4 Confirmation Sampling					\$37,770	
Develop Sampling and Analysis Plan (SAP)						168
Geologist	80	HR	\$121	\$9,660		100
Project Manager	20	HR	\$201	\$4,025		
Admin	20	HR	\$19	\$375		
Sampling	20	IIIC	\$17	<i>\$313</i>		
Sampling Team (two 2-person crews)	324	HR	\$98	\$31,671		79
Mileage Albuquerque, NM to Sites (1 round trip per week)	286	MI	\$0.54	\$155		1)
Per Diem (4 people)	32	DAY	\$142	\$4,601		
Miscellaneous Field Supplies and Expenses	1	LS	\$810	\$810		
Lab Analysis (15 samples per 2,000 m <sup>2</sup> survey area = 30 samples per acre) Reporting		EA	\$75	\$48,600		
Geologist	10	HR	\$121	\$1,208		
Project Manager	3	HR	\$201	\$503		
Project Engineer	3	HR	\$184	\$460		
CAD/GIS Operator	10	HR	\$98	\$978		
Admin	3	HR	\$19	\$47		
Copying	1	LS	\$34	\$34		
Subtotal Confirmation Sampling	•	20	Ψ	45.	\$103,125	
5 Mobilization/Demobilization (5% of Construction minus disposal fee)	1	LS	\$1,043,955	\$1,043,955	φ103,123	21
Subtotal Mob/Demob	•	20	,5,755	,,	\$1,043,955	
6 Improve/Blade Access Roads					,- 10,700	11
Improve/Blade Access Roads				\$147,828		••
Clearing and Grubbing				\$43,865		
Erosion and Sediment Control				\$44,032		
Drainage Crossings				\$170,083		
Subtotal Improve Access Road				,,,,,,,,	\$405,808	
7 Clearing and Grubbing					,	11
RSM 31 11 10.10 0100 - Crew B-7 (2 crews)						
Brush Chipper, 12"	22	DAY	\$987.11	\$21,716		
Crawler Loader and Operator (1)	22	DAY	\$2,097.07	\$46,135		
Chain Saw, Gas (2)	44	DAY	\$90.75	\$3,993		
Laborer (4)	880	HR	\$63.25	\$55,660		
RSM 31 13 13.10 0300 - Crew B-11A:	000		\$00.20	-22,000		
4						
Dozer, D-9 & Operator (1)	11	DAY	\$3,539.41	\$38,934		
Dozer, D-9 & Operator (1) Laborer (1)	11 110	DAY HR	\$3,539.41 \$100.63	\$38,934 \$11,069		

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### Table I-2 (Continued)

### Alternative 2 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

				C	CONSTRUCTION CO	NIRACIOR
8 Fence Construction / Repair						11
RSM 32 31 13.20 0800 - Crew B-80C	40.00			0205544		
Fence Materials (6 ga galvanized steel wire, 6' high)	10,207	LF	\$30.15	\$307,741		
Flatbed Truck (1)	11	DAY	\$932.77	\$10,260		
Manual Fence Post Auger (1)	11	DAY	\$882.36	\$9,706		
Laborer (2)	22	HR	\$63.25	\$1,392	#220 000	
Subtotal Fence Construction/Repair		LF	\$ 32.24		\$329,099	14
Erosion and Sediment Control						14
RSM 32 25 14.16- Crew B-62						
Silt Fence (material)	17,280	LF	\$1.93	\$33,343		
Hay Bales (material)	4,320	LF	\$7.25	\$31,320		
Loader, Skid Steer, 30 H.P and Operator. (1)	14	DAY	\$1,003.21	\$14,045		
Flatbed Truck and operator (1)	14	DAY	\$932.77	\$13,059		
Laborer (2)	56	HR	\$63.25	\$3,542		
Subtotal Erosion and Sediment Control			_		\$95,309	
On-Site Waste Excavation, Consolidation and Stockpiling						79
RSM 31 23 16.5 01000 - Crew B-33F (2 crews)						
Scraper (2) & Operator	158	DAY	\$3,133.00	\$495,014	J	
Dozer, D9 (1) & Operator	79	DAY	\$3,539.41	\$279,613	J	
Loader (1) & Operator	79	DAY	\$2,651.94	\$209,504	J	
Laborer (2)	1,580	HR	\$63.25	\$99,935	J	
Subtotal Waste Consolidation and Stockpiling	108,777	CYD	\$ 9.97	4,,,,,,,	\$1,084,066	
1 Backfill Borrow Excavation, Hauling, and Stockpile	100,777	CID	ψ ,,,,,		φ1,004,000	49
RSM 31 23 16.46 5540 - Crew B-10X (2 crews)						7)
Dozer, D-9 (460 HP) & Operator (1)	49	DAY	\$3,539.41	\$173,431		
Laborer (1)	490	HR	\$63.25	\$30,993		
RSM 31 23 23.15 6045 - Crew B-10T (2 crews)	470	IIIC	405.25	\$30,773		
Front End Loader, 3 CY bucket	49	DAY	\$2,651.94	\$129,945		
Laborer (1)	490	HR	\$63.25	\$30,993		
RSM 31 23 23.20 6180 - Crew 34G (2 crews)	490	IIK	\$03.23	\$30,993		
· · · · · · · · · · · · · · · · · · ·	92	DAY	\$2,213.87	\$203,676		
Haul Truck, 34 CY, Off-Road, 15 MPH, Cycle 2 miles (2 crews) Laborer	920 920	HR	\$63.25			
Subtotal Excavation, Hauling, and Stockpile of Clean Cover Material	108,777	CYD	\$ 5.77	\$58,190	# < 27 227	
	100,777	CID	\$ 5.77		\$627,227	61
2 Backfill Placement, Grading and Compaction						01
RSM 31 23 17 0190 - Crew B-10M (3 crews)	102	DAW	#1 150 <b>2</b> 0	6210.000		
Dozer, D-6 (300 HP) & Operator	182	DAY	\$1,159.28	\$210,990		
Laborer (1)	1,800	HR	\$63.25	\$113,850		
RSM 31 23 23.23 5080 - Crew 10Y						
Smooth Drum Roller, Riding	32	DAY	\$2,213.87	\$70,844		
Laborer (1)	310	HR	\$63.25	\$19,608		
Compaction Testing	14	EA	\$253.00	\$3,542		
Grader (1) & Operator	310	DAY	\$1,642.77	\$509,258	J	
Compaction Testing (1/1000 cyds)	109	EA	\$253.00	\$27,521	J	
Subtotal Backfill Placement, Grading and Compaction	108,777	CYD	\$ 8.79	,	\$955,611	
					φ. υυ, υπ	182
Transport and Disposal (Clean Harbors: Deer Trail, CO)					J	102
Loading: RSM 31 2323.15 6045 - Crew B-10T (2 crews)	264	D : **	# <b>0</b> - <b>**</b> - 0 :	0005.005	J	
Loader & Operator (2)	364	DAY	\$2,651.94	\$965,308	I	
Laborer (2)	3,620	HR	\$63.25	\$228,965	J	
Truck Tarp	40	EA	\$120.75	\$4,830	J	
Hauling: RSM 31 23 23.20 9714 (40 trucks/day)		B			J	
Dump truck (20 cyd highway)	7,280	DAY	\$1,447.30	\$10,536,344	J	
Truck Mobilization Fee	40	EA	\$1,289.15	\$51,566	I	
	3,988,490	\$/load mi	\$ 2.96		I	
Facility Disposal Fee	169,692	TON	\$75.00	\$12,726,909	I	
Subtotal Off-Site Transport and Disposal	169,692	TON	\$ 144.46		\$24,513,922	
Site Restoration (staging areas, general disturbance areas)					J	13
RSM 32 92 19.14 4600 - Crew B-81					J	
Flat Bed Truck & Operator (1)	13	DAY	\$932.77	\$12,126	I	
Power Mulcher (1)	13	DAY	\$1,135.34	\$14,759	J	
Laborer (1)	130	HR	\$63.25	\$8,223	J	
C. IN.	24	AC	\$1,357.11	\$32,571		
Seed Mix	24	710				
Fertilizer	24	AC	\$54.96	\$1,319	J	



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### Table I-2 (Continued)

### Alternative 2 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

				ш	CONSTRUCTION C	one.re.re.re
15 Contractor Site Overhead	250	DAYS				250
Project Manager (10% of time)	250	HR	\$201	\$50,313		
Site Superintendent	2,500	HR	\$98	\$244,375		
H&S Officer	2,500	HR	\$98	\$244,375		
QA/QC Officer	2,500	HR	\$98	\$244,375		
Site Foreman	2,500	HR	\$86	\$215,000		
Field Clerk	2,500	HR	\$19	\$46,875		
Site Vehicles - 4WD Trucks (6)	71	MO	\$4,500.00	\$321,429		
Site Personal Vehicles (4)	95	MO	\$1,000.00	\$95,238		
Mileage Grants, NM to Site (30 mi/each way)	150,000	MI	\$0.54	\$81,000		
Construction Crew Per Diem (15 people)	3,750	DAY	\$142	\$532,500		
Fuel for Site Vehicles (6)	71	MO	\$1,600.00	\$114,286		
Port-o-let Rental (4)	48	MO	\$416.00	\$19,810		
Job Trailers (2)	24	MO	\$269.00	\$6,405		
Storage Boxes (2)	24	MO	\$94.50	\$2,250		
Field Office Lights/HVAC (2)	24	MO	\$179.00	\$4,262		
	12	MO				
Telephone/internet (1)			\$96.00	\$1,143		
Field Office Equipment	12	MO	\$230.00	\$2,738		
Field Office Supplies	12	MO	\$96.00	\$1,143		
Trash (2 dumpsters)	24	MO	\$3,640.00	\$86,667		
Air Monitoring Equipment	12	MO	\$8,800.00	\$104,762		
Truck Scales	12	MO	\$300.00	\$3,571		
Construction Water, including hauling (excavation dust control)	217,554	GAL	\$0.05	\$10,878		
Construction Water, including hauling (hauling dust control)	3,915,972	GAL	\$0.05	\$195,799		
6000 Gallon Water Truck and Operator (2)	500	DAY	\$1,743.64	\$871,819		
Portable Water Tower Trailer, 10,000 gallons (2)	500	DAY	\$3,539.41	\$1,769,706		
Subtotal Contractor Site Overhead			15%		\$5,270,716	
SUBTOTAL CAPITAL COSTS:						
Planning, Engineering and Closeout		2.26%	of Construction		\$781,811	
Total Construction					\$34,649,971	
16 Construction Observation/Owner's Representative		6.0%	×	\$34,649,971	\$2,078,998	
Subtotal					\$37,510,780	
17 Allowance for Level of Accuracy		25%	×	\$37,510,780	\$9,377,695	
Subtotal					\$46,888,475	
18 Indirect Costs - 8%		8%	×	\$46,888,475	\$3,751,078	
TOTAL CAPITAL COSTS:				=	\$50,639,553	
PRSC COSTS (O & M):					φ50,057,555	
<u>PRSC COSTS (O &amp; M):</u>						
19 Annual Cost for Year 1 to 12						
Quarterly Inspections (2 person crew, 1 day, 10 hrs/day)	80	HR	\$98	\$7,820		
Mileage Albuquerque, NM to Site (round trip)	848	MI	\$0.54	\$458		
Inspection Crew Per Diem	8	DAY	\$140	\$1,120		
Preparation of Semi-annual Reports (Professional Engineer)	40	HR	\$138	\$5,520		
Assumed Annual Maintenance Costs (revegetation, watering, fence repairs)	1	LS	\$20,000	\$20,000		
	-		,	,	#2.10T	
TOTAL ANNUAL COST (YEAR 1 TO 12)					\$34,918	
20 Annual Cost for Year 13 to 99						
Annual Inspection (2 person crew, 2 days, 10hrs/day)	0	HR	\$98	\$0		
Mileage Albuquerque, NM to Site (round trip)	0	MI	\$0.555	\$0		
Inspection Crew Per Diem	0	DAY	\$129	\$0		
Assumed Annual Maintenance Costs	0	LS	\$10,000	\$0		
Preparation of Annual Report (Professional Engineer)	0	HR	\$138	\$0_		
TOTAL ANNUAL COST (YEAR 13 TO 99)				=	\$0	
					φυ	

Abbreviations:

MI = Mile



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## Table I-3 Alternative 3 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

Item Description	Quantity	Unit	Unit Cost	Extension	Item Total	Duration
CAPITAL COSTS:	Çy					(work days
1 Engineering Design						252
Project Manager	202	HR	\$201	\$40,572		
Project Engineer	1,210	HR	\$184	\$222,566		
Design Engineer (2)	3,226	HR	\$115	\$370,944		
CAD/GIS Operator	1,613	HR	\$98	\$157,651		
Admin	202	HR	\$19	\$3,780		
Expenses	1	LS	\$5,000	\$5,000		
Subtotal Engineering Costs		10%	· -		\$800,514	
2 Planning Documents						168
Project Manager	134	HR	\$201	\$27,048		
Project Engineer	1,075	HR	\$184	\$197,837		
CAD/GIS Operator	323	HR	\$98	\$31,530		
Admin	67	HR	\$19	\$1,260		
Expenses	1	LS	\$1,000	\$1,000		
Subtotal Planning Documents			_		\$258,675	
3 Resource Surveys						168
Geotechnical Testing and Report	2	EA	\$25,000	\$50,000		
Pre-Project Aerial LIDAR Survey	22	AC	\$180	\$3,888		
Post-Project Aerial LIDAR Survey	22	AC	\$180	\$3,888		
Subtotal Resource Surveys			_		\$57,776	
4 Confirmation Sampling						
Develop Sampling and Analysis Plan (SAP)						168
Geologist	80	HR	\$121	\$9,660		
Project Manager	20	HR	\$201	\$4,025		
Admin	20	HR	\$19	\$375		
Sampling						49
Sampling Team (two 2-person crews)	324	HR	\$98	\$31,671		
Mileage Albuquerque, NM to Sites (1 round trip per week)	286	MI	\$0.54	\$155		
Per Diem (4 people)	32	DAY	\$142	\$4,601		
Miscellaneous Field Supplies and Expenses	1	LS	\$810	\$810		
Lab Analysis (15 samples per 2,000 m <sup>2</sup> survey area = 30 samples per acre)	648	EA	\$75	\$48,600		
Reporting						
Geologist	10	HR	\$121	\$1,208		
Project Manager	3	HR	\$201	\$503		
Project Engineer	3	HR	\$184	\$460		
CAD/GIS Operator	10	HR	\$98	\$978		
Admin	3	HR	\$19	\$47		
Copying	1	LS	\$34	\$34		
Subtotal Confirmation Sampling			=		\$103,125	
5 Mobilization/Demobilization (5% of Construction)	1	LS	\$390,863	\$390,863		21
Subtotal Mob/Demob					\$390,863	
6 Improve/Blade Access Road						11
Improve/Blade Access Roads				\$147,828		
Clearing and Grubbing				\$43,865		
Erosion and Sediment Control				\$44,032		
Drainage Crossings				\$170,083		
Subtotal Improve/Blade Access Road					\$405,808	
7 Clearing and Grubbing						13
RSM 31 11 10.10 0100 - Crew B-7 (2 crews)						
Brush Chipper, 12"	26	DAY	\$987.11	\$25,665		
Crawler Loader and Operator (1)	26	DAY	\$2,097.07	\$23,003 \$54,524		
Chain Saw, Gas (2)	52	DAY	\$2,097.07	\$34,324 \$4,719		
Chain Saw, Gas (2) Laborer (4)	1,040	HR	\$90.75 \$63.25	\$65,780		
RSM 31 13 13.10 0300 - Crew B-11A:	1,040	пк	\$03.25	\$00,780		
	12	DAV	¢2 520 41	\$46.012		
Dozer, D-9 & Operator (1)	13	DAY	\$3,539.41 \$100.63	\$46,012		
Laborer (1)	130	HR	\$100.63	\$13,082	\$200.703	
Subtotal Clearing and Grubbing	121,000	SYD			\$209,782	27
Fence Construction / Repair (2 crews)						26
RSM 32 31 13.20 0800 - Crew B-80C						
Fence Materials (6 ga galvanized steel wire, 6' high)	12,677	LF	\$30.15	\$382,212		
Flatbed Truck (1)	26	DAY	\$932.77	\$24,252		
Manual Fence Post Auger (1)	26	DAY	\$882.36	\$22,941		
Laborer (2)	52	HR	\$63.25	\$3,289		
Subtotal Fence Construction/Repair	12677	LF	\$34		\$432,694	Ī



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### Table I-3 (Continued)

### Alternative 3 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

					_	CONSTRUCTION CO	
9 Ero	osion and Sediment Control						14
	RSM 32 25 14.16- Crew B-62						
	Silt Fence (material)	17,280	LF	\$1.93	\$33,343		
	Hay Bales (material)	4,320	LF	\$7.25	\$31,320		
	· · · · · · · · · · · · · · · · · · ·			\$1,003.21	\$14,045		
	Loader, Skid Steer, 30 H.P and Operator. (1)	14	DAY				
	Flatbed Truck and operator (1)	14	DAY	\$932.77	\$13,059		
	Laborer (2)	56	HR	\$63.25	\$3,542	\$05.200	
	btotal Erosion and Sediment Control					\$95,309	49
	n-Site Waste Excavation, Consolidation and Stockpiling						49
	RSM 31 23 16.46 5540 - Crew B-10X (2 crews)	0.0	DAY	62 520 41	6246.062		
	Dozer, D-9 (460 HP) & Operator	98	DAY	\$3,539.41	\$346,862		
	Laborer	980	HR	\$63.25	\$61,985		
	RSM 31 23 23.15 6045 - Crew B-10T (2 crews)	00	D.177	00 (51 04	#250 001		
	Front End Loader, 3 CY bucket	98	DAY	\$2,651.94	\$259,891		
	Laborer	980	HR	\$63.25	\$61,985		
	RSM 31 23 23.20 6180 - Crew 34G (4 crews)						
	Haul Truck, 34 CY, Off-Road, 15 MPH, Cycle 2 miles	184	DAY	\$2,213.87	\$407,351		
	Laborer	1,840	HR	\$63.25	\$116,380		
	btotal Excavation, Transportation, and Stockpile of Waste Soil (0-2')	108,777	CYD	\$ 11.53		\$1,254,454	
1 Bac	ckfill and Cap Borrow Excavation, Hauling, and Stockpile						79
	RSM 31 23 16.46 5540 - Crew B-10X						
	Dozer, D-9 (460 HP) & Operator (1)	79	DAY	\$3,539.41	\$279,613		
	Laborer (1)	780	HR	\$63.25	\$49,335		
	RSM 31 23 23.15 6045 - Crew B-10T						
	Front End Loader, 3 CY bucket (2)	79	DAY	\$2,651.94	\$209,504		
	Laborer (1)	780	HR	\$63.25	\$49,335		
	RSM 31 23 23.20 6180 - Crew 34G x2			_			
	Haul Truck, 34 CY, Off-Road, 15 MPH, Cycle 2 miles (2)	148	DAY	\$2,213.87	\$327,652		
	Laborer (1)	1,480	HR	\$63.25	\$93,610		
Sub	btotal Excavation, Transportation, and Stockpile of Clean Cover Material	87,522	CYD	\$ 11.53		\$1,009,049	
2 Bac	ckfill Placement, Grading and Compaction (2' Excavations)					, ,,.	34
	RSM 31 23 17 0190 - Crew B-10M (3 crews)						٠.
		101	DAY	\$932.77	\$94,209		
	Dozer, D-6 (300 HP) & Operator Laborer (1)	1,020	HR	\$63.25	\$64,515		
	**	1,020	пк	\$03.23	\$04,313		
	RSM 31 23 23.23 5080 - Crew 10Y	10	DAY	61 150 20	620.077		
	Smooth Drum Roller, Riding	18 170	DAY	\$1,159.28	\$20,867		
	Laborer (1)		HR	\$63.25	\$10,753		
	Compaction Testing	14	EA	\$253.00	\$3,542		
	Grader (1) & Operator	170	DAY	\$1,642.77	\$279,270		
	Compaction Testing	14	EA	\$253.00	\$3,611		
	btotal Backfill Placement, Grading and Compaction	60,553	CYD	\$ 7.87		\$476,768	
3 Con	onstruction of Waste Cell - Spread waste soil, compact & grade						
	RSM 31 23 17 0190 - Crew B-10M (3 crews)						34
							34
	Dozer, D-6 (300 HP) & Operator (1)	102	DAY	\$2,061.53	\$210,276		34
		102 1,020	DAY HR	\$2,061.53 \$63.25	\$210,276 \$64,515		34
	Dozer, D-6 (300 HP) & Operator (1) Laborer (1)						34
	Dozer, D-6 (300 HP) & Operator (1)	1,020		\$63.25	\$64,515		34
	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding	1,020 18	HR DAY	\$63.25 \$1,382.41	\$64,515 \$24,883		34
	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1)	1,020 18 170	HR DAY HR	\$63.25 \$1,382.41 \$63.25	\$64,515 \$24,883 \$10,753		34
	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing	1,020 18 170 40	HR DAY HR EA	\$63.25 \$1,382.41 \$63.25 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160		34
	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator	1,020 18 170 40 18	HR DAY HR EA DAY	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77	\$64,515 \$24,883 \$10,753	\$350 I57	34
Sub	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell	1,020 18 170 40	HR DAY HR EA	\$63.25 \$1,382.41 \$63.25 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell instruction of Soil Cap	1,020 18 170 40 18	HR DAY HR EA DAY	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77	\$64,515 \$24,883 \$10,753 \$10,160	\$350,157	34
Sub Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator bitotal Construction of Waste Cell instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3	1,020 18 170 40 18 60,553	HR DAY HR EA DAY CYD	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$5.78	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator bitial Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1)	1,020 18 170 40 18 60,553	HR DAY HR EA DAY CYD	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator btotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1)	1,020 18 170 40 18 60,553	HR DAY HR EA DAY CYD	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$5.78	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y	1,020  18 170 40 18 60,553	HR DAY HR EA DAY CYD DAY HR	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$5.78	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding	1,020  18 170 40 18 60,553	HR DAY HR EA DAY CYD DAY HR	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell mstruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1)	1,020  18 170 40 18 60,553  45 450 8 80	HR DAY HR EA DAY CYD DAY HR	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$0.00 \$63.25	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding	1,020  18 170 40 18 60,553	HR DAY HR EA DAY CYD DAY HR	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell mstruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1)	1,020  18 170 40 18 60,553  45 450 8 80	HR DAY HR EA DAY CYD DAY HR	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$0.00 \$63.25	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator btotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing	1,020  18 170 40 18 60,553  45 450 8 80 14	HR DAY HR EA DAY CYD DAY HR DAY HR EA	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$5.78 \$0.00 \$63.25 \$0.00 \$63.25	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060 \$3,542	\$350,157	
Sub 4 Con	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator Compaction Testing	1,020  18 170 40 18 60,553  45 450 8 80 14 80 14	HR  DAY HR EA DAY CYD  DAY HR  DAY HR DAY EA  DAY EA	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$253.00 \$1,642.77 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060 \$3,542 \$131,421		
Sub 4 Con Sub	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator Compaction Testing biotal Construction of Clean Soil Cover	1,020  18 170 40 18 60,553  45 450 8 80 14 80	HR DAY HR EA DAY CYD DAY HR DAY HR DAY DAY HR DAY	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$253.00 \$1,642.77 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060 \$3,542 \$131,421	\$350,157 \$172,097	15
Sub Sub Sub Sub Sub Sub Sub	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator Compaction Testing biotal Construction of Clean Soil Cover Restoration (staging areas, general disturbance areas & cap)	1,020  18 170 40 18 60,553  45 450 8 80 14 80 14	HR  DAY HR EA DAY CYD  DAY HR  DAY HR DAY EA  DAY EA	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$253.00 \$1,642.77 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060 \$3,542 \$131,421		
Sub	Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator biotal Construction of Waste Cell Instruction of Soil Cap RSM 31 23 17 0190 - Crew B-10M x3 Dozer, D-6 (300 HP) & Operator (1) Laborer (1) RSM 31 23 23.23 5080 - Crew 10Y Smooth Drum Roller, Riding Laborer (1) Compaction Testing Grader (1) & Operator Compaction Testing biotal Construction of Clean Soil Cover	1,020  18 170 40 18 60,553  45 450 8 80 14 80 14	HR  DAY HR EA DAY CYD  DAY HR  DAY HR DAY EA  DAY EA	\$63.25 \$1,382.41 \$63.25 \$253.00 \$1,642.77 \$ 5.78 \$0.00 \$63.25 \$253.00 \$1,642.77 \$253.00	\$64,515 \$24,883 \$10,753 \$10,160 \$29,570 \$0 \$28,463 \$0 \$5,060 \$3,542 \$131,421		15



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### Table I-3 (Continued)

### Alternative 3 - Preliminary Construction Cost Estimate Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Effort Legend
START CONTRACTOR / EPA
CONSTRUCTION CONTRACTOR

Laborer (1)	150	HR	\$63.25	\$9,488		
Seed Mix	21	AC	\$1,357.11	\$28,499		
Fertilizer	21	AC	\$54.96	\$1,154		
Mulch	21	AC	\$3,239.56	\$68,031		
Subtotal Site Restoration	21	AC	\$6,581		\$138,193	
16 Contractor Site Overhead	227.0	DAYS OR	11	MONTHS		227
Project Manager (10% of time)	227	HR	\$201	\$45,684		
Site Superintendent	2,270	HR	\$98	\$221,893		
H&S Officer	2,270	HR	\$98	\$221,893		
QA/QC Officer	2,270	HR	\$98	\$221,893		
Site Foreman	2,270	HR	\$86	\$195,220		
Field Clerk	2,270	HR	\$19	\$42,563		
Site Vehicles - 4WD Trucks (6)	65	MO	\$4,500.00	\$291,857		
Site Personal Vehicles (4)	86	MO	\$1,000.00	\$86,476		
Mileage Grants, NM to Site (30 mi/each way)	136,200	MI	\$0.54	\$73,548		
Construction Crew Per Diem (15 people)	3,405	DAY	\$142	\$483,510		
Fuel for Site Vehicles (6)	65	MO	\$1,600.00	\$103,771		
Port-o-let Rental (4)	43	MO	\$416.00	\$17,987		
Job Trailers (2)	22	MO	\$269.00	\$5,816		
Storage Boxes (2)	22	MO	\$94.50	\$2,043		
Field Office Lights/HVAC (2)	22	MO	\$179.00	\$3,870		
Telephone/internet (1)	11	MO	\$96.00	\$1,038		
Field Office Equipment	11	MO	\$230.00	\$2,486		
Field Office Supplies	11	MO	\$96.00	\$1,038		
Trash (2 dumpsters)	22	MO	\$3,640.00	\$78,693		
Air Monitoring Equipment	11	MO	\$8,800.00	\$95,124		
Truck Scales	0	MO	\$300.00	\$0		
Construction Water, including hauling (excavation dust control)	217,554	GAL	\$0.05	\$10,878		
Construction Water, including hauling (hauling dust control)	3,915,972	GAL	\$0.05	\$195,799		
6000 Gallon Water Truck and Operator (2)	454	DAY	\$1,743.64	\$791,612		
Portable Water Tower Trailer, 10,000 gallons (2)	454	DAY	\$172.36	\$78,252		
Subtotal Contractor Site Overhead			40%	-,0,202	\$3,272,941	
SUBTOTAL CAPITAL COSTS:					,,	
Planning, Engineering and Closeout		14.86%	of Construction		\$1,220,090	
Total Construction		17.00/0	or Construction		\$8,208,115	
16 Construction Observation/Owner's Representative		6.0%	×	\$8,208,115	\$492,487	
Subtotal		0.070	^	Ψ0,200,113	\$9,920,692	
17 Allowance for Level of Accuracy		25%	x	\$9,920,692	\$9,920,092	
Subtotal		2370	X	\$7,720,092	\$12,400,864	
18 Indirect Costs - 8% (Items 1 - 17, and 19)		8%		\$12,400,864	\$12,400,864	
TOTAL CAPITAL COSTS:		870	x	φ12, <del>1</del> 00,004		
PRSC COSTS (O & M):					\$13,392,934	
	80	HR	600	67.020		
Quarterly Inspections (2 person crew, 1 day, 10 hrs/day)	80 848	HR MI	\$98 \$0.54	\$7,820 \$458		
Mileage Albuquerque, NM to Site (round trip)				\$458		
Inspection Crew Per Diem	8	DAY	\$140	\$1,120		
Preparation of Semi-annual Reports (Professional Engineer)	40	HR	\$138	\$5,520		
Assumed Annual Maintenance Costs (revegetation, watering, fence repairs)	1	LS	\$20,000	\$20,000		
TOTAL ANNUAL COST (YEAR 1 TO 12)					\$27,098	
20 Annual Cost for Year 13 to 99						
Annual Inspection (2 person crew, 2 days, 10hrs/day)	40	HR	\$98	\$3,910		
Mileage Albuquerque, NM to Site (round trip)	212	MI	\$0.555	\$118		
Inspection Crew Per Diem	4	DAY	\$129	\$516		
Assumed Annual Maintenance Costs	1	LS	\$10,000	\$10,000		
Preparation of Annual Report (Professional Engineer)	40	HR	\$138	\$5,520		
TOTAL ANNUAL COST (YEAR 13 TO 99)				=	\$16,154	
					,10,107	

Abbreviations:

MI = Mile



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## Table I-4 Equipment and Personnel Rates Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Reference: RS Means Heavy Construction Cost Data 2020

Equipment and Operator Unit Costs for the Sections 32 and 33 Mines Site

Equipment and Operator Unit Costs for the Sections 32 and 33 Mi  Equipment/Personnel	RS Means	Equipment Hourly Operating Cost	Equipment Renta	ll Equipment Cost per Day	EPA Provided Operator/ Driver Hourly Rate	Equipment + Operator	Total per Day, including O&P
Manual Fence Post Auger	RSM 01 54 33.20 0095	\$ 0.45	\$ 755.00	33.86	\$ 84.85	\$ 882.36	\$ 882.36
Backhoe Loader (40 hp)	RSM 01 54 33.20 0400	\$ 11.86	\$ 2,200.00	\$ 204.16	\$ 84.85	\$ 1,052.66	\$ 1,052.66
Excavator (7 CY)	RSM 01 54 33.20 0340	\$ 174.67	\$ 30,600.00	\$ 2,936.70	\$ 84.85	\$ 3,785.20	\$ 3,785.20
Brush Chipper, 12" (130 hp)	RSM 01 54 33.20 0550	\$ 23.60	\$ 3,050.00	\$ 354.61	\$ 63.25	\$ 987.11	\$ 987.11
Grader (30,000 lbs)	RSM 01 54 33.20 1910	\$ 32.76	\$ 12,000.00	) \$ 794.27	\$ 84.85	\$ 1,642.77	\$ 1,642.77
Power Mulcher	RSM 01 54 33.20 2860	\$ 17.99	\$ 2,750.00	\$ 286.84	\$ 84.85	\$ 1,135.34	\$ 1,135.34
Sheepsfoot Roller, Towed (50 hp)	RSM 01 54 33.20 3150	\$ 25.56	\$ 3,475.00	\$ 390.74	\$ -	\$ 390.74	\$ 390.74
Smooth Drum Vibratory Roller, (125 hp)	RSM 01 54 33.20 3400	\$ 27.53	\$ 6,650.00	533.91	\$ 84.85	\$ 1,382.41	\$ 1,382.41
Scraper (21 cy)	RSM 01 54 33.20 3550	\$ 140.95	\$ 22,500.00	\$ 2,284.50	\$ 84.85	\$ 3,133.00	\$ 3,133.00
Dozer, D-6 (200 hp)	RSM 01 54 33.20 4260	\$ 62.97	\$ 15,000.00	\$ 1,213.03	\$ 84.85	\$ 2,061.53	\$ 2,061.53
Dozer, D-9 (500 hp)	RSM 01 54 33.20 4370	\$ 132.98	\$ 35,000.00	2,690.91	\$ 84.85	\$ 3,539.41	\$ 3,539.41
Crawler Loader (3 CY)	RSM 01 54 33.20 4560	\$ 71.19	\$ 13,800.00	) \$ 1,248.57	\$ 84.85	\$ 2,097.07	\$ 2,097.07
Front End Loader (8 CY)	RSM 01 54 33.20 4810	\$ 90.90	\$ 23,000.00	\$ 1,803.44	\$ 84.85	\$ 2,651.94	\$ 2,651.94
1 Loader, Skid Steer (30 hp)	RSM 01 54 33.20 4880	\$ 9.54	\$ 1,525.00	\$ 154.71	\$ 84.85	\$ 1,003.21	\$ 1,003.21
Dump Trail Only (20 CY)	RSM 01 54 33.20 5400	\$ 6.18	\$ 1,525.00	\$ 121.11	\$ -	\$ 121.11	\$ 121.11
Dump Truck, 34 CY, Off-Road (50 ton)	RSM 01 54 33.20 5610	\$ 83.87	\$ 16,500.00	) \$ 1,480.37	\$ 73.35	\$ 2,213.87	\$ 2,213.87
Dump Truck, 20 CY, Highway rated	RSM 01 54 33.20 5310			\$ 713.80	\$ 73.35	\$ 1,447.30	\$ 1,447.30
Tractor, with Attachment	RSM 01 54 33.40 6465	\$ 17.37	\$ 3,525.00	\$ 310.78	\$ 84.85	\$ 1,159.28	\$ 1,159.28
6,000 Gal Water Truck	RSM 01 54 33.40 6950	\$ 71.75	\$ 7,525.00	\$ 1,010.14	\$ 73.35	\$ 1,743.64	\$ 1,743.64
Flatbed Truck (20,000 lb)	RSM 01 54 33.40 7290	\$ 15.26	\$ 1,200.00	\$ 199.27	\$ 73.35	\$ 932.77	\$ 932.77
Truck Tractor, 6 x 4 (450 hp)	RSM 01 54 33.40 7600	\$ 44.23	\$ 3,725.00	\$ 587.16	\$ 73.35	\$ 1,320.66	\$ 1,320.66
Portable Water Tower Trailer, 10,000 gallons	RSM 01 54 33.40.6925	\$ 9.75	\$ 1,925.00	) \$ 172.36	\$ -	\$ 172.36	\$ 172.36
Pump, Concrete, Truck Mounted, 4" Line, 80' Boom	RSM 01 54 33.10.2120	\$ 29.79	\$ 2,575.00	\$ 398.04	\$ 73.35	\$ 1,131.54	\$ 1,131.54
Chain Saws, Gas				\$ 90.75	\$ -	\$ 90.75	\$ 90.75
Hydraulic Crane, 25 ton	RSM 01 54 19.50 0500	\$ 36.36		\$ 485.00	\$ 84.85	\$ 1,333.50	\$ 1,333.50
Hydraulic Crane, 55 ton	RSM 01 54 33 2600	\$ 53.78		\$ 915.00	\$ 84.85	\$ 1,763.50	\$ 1,763.50
Hydraulic Crane, 80 ton	RSM 01 54 19.50 0201	\$ 75.71		\$ 1,475.00	\$ 84.85	\$ 2,323.50	\$ 2,323.50



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### Table I-4 (Continued)

### **Equipment and Personnel Rates**

### Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

Construction and Engineering Personnel Rates for the Sections 32 and 33 Mines Site

Personnel	Source	Source Hourly Rate		Daily Rate
Truck Driver (Heavy)	RS Means Labor Data	\$	73.35	\$ 733.50
Laborer	RS Means Labor Data	\$	63.25	\$ 632.50
Foreman (Outside)	RS Means Labor Data	\$	86.00	\$ 860.00
Equipment Operator (Medium)	RS Means Labor Data	\$	84.85	\$ 848.50
Site Superintendent (maximum)	RSM 01 31 13.20	\$	100.63	\$ 1,006.30
Admin (Clerk)	RSM 01 31 13.20	\$	18.75	\$ 187.50
Sampling Team/Scientist		\$	97.75	\$ 977.50
CAD/GIS Operator		\$	97.75	\$ 977.50
Design Engineer		\$	115.00	\$ 1,150.00
Geologist		\$	120.75	\$ 1,207.50
Professional Engineer		\$	138.00	\$ 1,380.00
Project Engineer		\$	184.00	\$ 1,840.00
Project Manager		\$	201.25	\$ 2,012.50

#### Per Diem and Mileage Rates

Allowance	Source	Lodging	M&IE	Total
Per Diem Rate (per Day)	www.gsa.gov	\$ 96.00	\$ 55.00	\$ 151.00
Mileage Rate (per Mile)	www.gsa.gov			\$ 0.58



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#### Table I-5

### Material and Work Quantities and Unit Prices Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

#### **Waste Material Earthwork Areas and Volumes**

	Depth	Surrace Area	Surface Area	volume	Volume		
Removal Volume Estimates*	(ft)	(ft <sup>2</sup> )	(Acres)	(ft <sup>3</sup> )	(CY)		
Waste Material Volume							
2-ft Excavation Area	2	817,455	18.8	1,634,910	60,553		
Section 32 Waste Stockpile	-	121,840	2.8	1,302,048	48,224		
Totals of Excavation*		939,295.00	21.60	2,936,958.00	108,777.00		
Transported Volume, CY	Applying a 20%	Swell Factor (x 1.2	!)		130,532		
Transported Weight, TONS	Assuming 1.3 To	ons per CY (x 1.3)			169,692		
Truck loads	34 cubic yard o	ff-road vehicle less	10% for payload qty		4,223		
* Table 2-1. Removal Volume Estimates							
Backfill Soil for Waste Excavation Area							
Alternative 2 - Offsite Disposal					108,777		
Alternative 3 - Consolidation and Cap in Place					60,553		
Alternative 2 - Backfill for 2'-excavation restoration					60,553		
Alternative 3 - Backfill for final cap					26,969		
Alternative 3 - Cap-in-Place Cap Volume (221,889 sf)							
Estimated Cap Footprint, Acres					5.89		
Estimated Cap Footprint, SY					28,508		
Estimated Cap Footprint, Square Feet					256,568		
Total Fill Volume of Cap-in-Place, cubic yard (C3D Volu		108,553					
ET Cover volume, cubic yard (24" thick)	18,094						
Radiation attenuation barrier volume, cubic yard (30 cm or	diation attenuation barrier volume, cubic yard (30 cm or 12" thick)						
Cap Volume, cubic yard (C3D Volume)	Cap Volume, cubic yard (C3D Volume)						
Total Backfill, cubic yard (2' excvation restoration & fir		87,522					

#### C3D Volumes

#### QUANTITIES CALCULATIONS

 ESTIMATED VOLUME OF EXISTING WASTE PILE (CUYD):
 47,995

 INFILL VOLUME, EXCLUDING EXISTING WASTE PILE (CUYD):
 60,958

 TOTAL VOLUME OF INFILL (CUYD):
 108,552

 TARGET VOLUME OF INFILL (CUYD):
 8,875

 RADON BARRIER VOLUME (CUYD)
 8,875

 EVAPOTRANSPIRATION LAYER (CUYD)
 18,094

 TOTAL AREA (ACRES)
 5,89

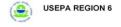
 BOUNDARY FENCE (LF)
 2,470

#### Revegetation Areas

Revegetation Area - Alternative 2	(ft²)	(acres)	(MSF)
2-ft Excavation area	817,455	18.77	817.46
Section 32 waste pile	121,840	2.80	121.84
Add 10% of Staging & Other Disturbed Areas		2.16	93.93
Total Alternative 2		23.72	1,033.22
Revegetation Area - Alternative 3	(ft²)	(acres)	(MSF)
2-ft Excavation area	817,455	18.77	817.46
Section 32 Cap	256,568	1.88	256.57
Add 10% of Staging & Other Disturbed Areas		20.64	107.40
Total Alternative 3			1,181.43

#### Study Area Quantities and Unit Costs

Work Item	Quantity	Unit	U	Unit Price		Extended Cost	Reference	Assumptions
								Cultural study has been performed
Cultural Resources Mitigation	1	Each	\$	200,000.00	\$	200,000.00	Vendor's Quote	but number of sites have not be
Geotechnical Testing and Report	2	Each	\$	25,000.00	\$	50,000.00	RSM 02 32 13.10	Assumed two studies for project
Aerial Survey (LIDAR)	22	AC	\$	180.00	\$	3,888.00	RSM 02 21 13.16 2000	Assumed price x2 due to small area



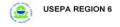
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## Table I-5 (Continued) Material and Work Quantities and Unit Prices Navajo Area Uranium Mines, Sections 32 and 33 Mines Site McKinley County, New Mexico

#### Material Quantities and Unit Prices

Work Item	Quantity	Unit	Unit Price (x Factor)	E	Extended Cost	Reference	Assumptions
Road Gravel (Materials)	11,734	SY	\$ 13.12	\$	153,894.34	RSM 01 55 23.50 0100	1 miles of road, 20 feet wide
Fence Repair (Materials)	2,640	LF	\$ 30.15	\$	79,596.00	RSM 32 31 13.20 0200	See access roads option
Silt Fence (Materials)	17,280	LF	\$ 1.93	\$	33,343.49	RSM 31 25 14.16 1000	Assumed 800 feet required per acre
Sediment Log, filter Sock, 12"	4,320	LF	\$ 7.25	\$	31.32	RSM 32 91 13.16 0350	
Seeds (Materials) - All Alternatives	817	AC	\$ 1,357.11	\$	1,109,377.83	RSM 32 92 19.14 5300	
Soil Amendments (Humate) (Materials) - All Alternatives	817	AC	\$ 123,672.29	\$	101,096,527.73	RSM 32 91 13.23 4050	Assumed \$250/ton delivered, at 700 lb/acre
Fertilizer (Materials) - All Alternatives	817	AC	\$ 54.96	\$	44,930.15	RSM 32 91 13.23 4150	
Multch (Materials) - All Alternatives	817	AC	\$ 3,239.56	\$	2,648,192.23	RSM 32 91 13.16 0700	
Waste Soil Disposal Fee	169,692	TON	\$ 75.00	\$	12,726,909.00	Facility Quote	Assumed 1.3 tons per CY, and 20% swell
Truck Mobilization Fee	0	Each	\$ 1,289.15	\$	-	Facility Quote	Assumed 300 trucks, 2-day rotation
Truck Tarp	0	Each	\$ 120.75	\$		Facility Quote	Assumed 300 trucks, 2-day rotation Assumed a 138 kV Transmossion
Job Trailers	1	МО	\$ 269.00	\$	269.00	RSM 01 52 13.20 0350	Trai
							Assumed a 138 kV Transmossion
Storage Boxes	1	MO	\$ 94.50	\$	94.50	RSM 01 52 13.20 1250	Boxe
Field Office Lights/HVAC	1	МО	\$ 179.00	\$	179.00	RSM 01 52 13.40 0160	Assumed a 138 kV Transmossion Ligh Assumed a 138 kV Transmossion
Telephone/internet	1	МО	\$ 96.00	\$	96.00	RSM 01 52 13.40 0140	Tele
Portable Toilet	2	MO	\$ 208.00	\$	416.00	RSM 01 54 33.40 6410	A
Field Office Equipment	1	МО	\$ 230.00	\$	230.00	RSM 01 52 13.40 0100	Assumed a 138 kV Transmossion Equi
Field Office Supplies	1	МО	\$ 96.00	\$	96.00	RSM 01 52 13.40 0120	Assumed a 138 kV Transmossion Supp
Trash(2 dumpsters, 6CY capacity)	4	WEEK	\$ 455.00	\$	3,640.00	RSM 02 41 19.19 0600	Assumed a 138 kV Transmossion dump
Air Monitoring Equipment	2	МО	\$ 4,400.00	\$	8,800.00	Vendor Quote	Assumed a 138 kV Transmossion Equi
Site Vehicles- 4WD Trucks	3	МО	\$ 1,500.00	\$	4,500.00	RSM 01 54 33.40 7200	
Site Vehicles	2	МО	\$ 500.00	\$	1,000.00	Engineering Estimate	
Fuel for Vehicles	1	МО	\$ 1,600.00	\$	1,600.00	Engineering Estimate	\$2.40/gal, 15 mi/gal, 10,000 miles/month
Truck Scales	1	МО	\$ 300.00	\$	300.00	Engineering Estimate	Assumed a 138 kV Transmossion Scal
Construction Water, including Hauling - Alternative 2	4,133,526	GAL	\$ 0.05	\$	206,676.30	Engineering Estimate	Assumed 2 gal/CY for excavation, 30 gal/CY for hauling dust control
Construction Water, including Hauling - Alternative 3	1,302,000	GAL	\$ 0.05	\$	65,100.00	Engineering Estimate	Assumed 2 gal/CY for excavation, 30 gal/CY for hauling dust control
Portable Water Tower Trailer, 10,000 gallons	2	EA	\$ 25,300.00	\$	50,600.00	RSM 33 16 36.16 0100	
Compaction Test (Field) - Alternative 3	34	EA	\$ 253.00	\$	8,691.31	RS Means 01 45 23.50 49	Assumed 1 test per 2,000 CY
Radiological Confirmation Sample (Lab) - Alternative 2	648	EA	\$ 75.00	\$	48,600.00	Engineering Estimate	\$60/lab sample, \$15/sample for shipping
Radiological Confirmation Sample (Lab) - Alternative 3	660	EA	\$ 75.00	\$	49,500.00	Engineering Estimate	\$60/lab sample, \$15/sample for shipping
Radiological Confirmation Sample (Lab) - Alternative 4	648	EA	\$ 75.00	\$	48,600.00	Engineering Estimate	\$60/lab sample, \$15/sample for shipping

Reference: RS Means Heavy Construction Cost Data 2020



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#### Table I-6

## Location Adjustment Factors for Gallup, New Mexico Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines McKinley County, New Mexico

Reference: RS Means Heavy Construction Cost Data 2020

The majority of the work will be Excavation (as defined by RS Means) by Equipment Operators, Laborers, and Foremen

#### Labor<sup>1</sup>

	Gallup, NM		
	Installation		
Category	Factor		
Excavation	0.975		

#### Materials<sup>2</sup>

Gallup, NM
Materials
Factor
1.005

#### Equipment<sup>3</sup>

Gallup, NM
Equipment
Factor
1.075

#### Time<sup>4</sup>

Historical C		
January 2020	Time Feeter	
January 2020	January 2016	Time Factor
239.1	207.3	1 15

<sup>&</sup>lt;sup>1</sup> Labor factor is based on the Gallup, New Mexico city cost index for Site and Infrastructure, Demolition (RSMeans, page 635). Workers Comp % is based on New Mexico rates for Excavation (RSMeans, page 669).

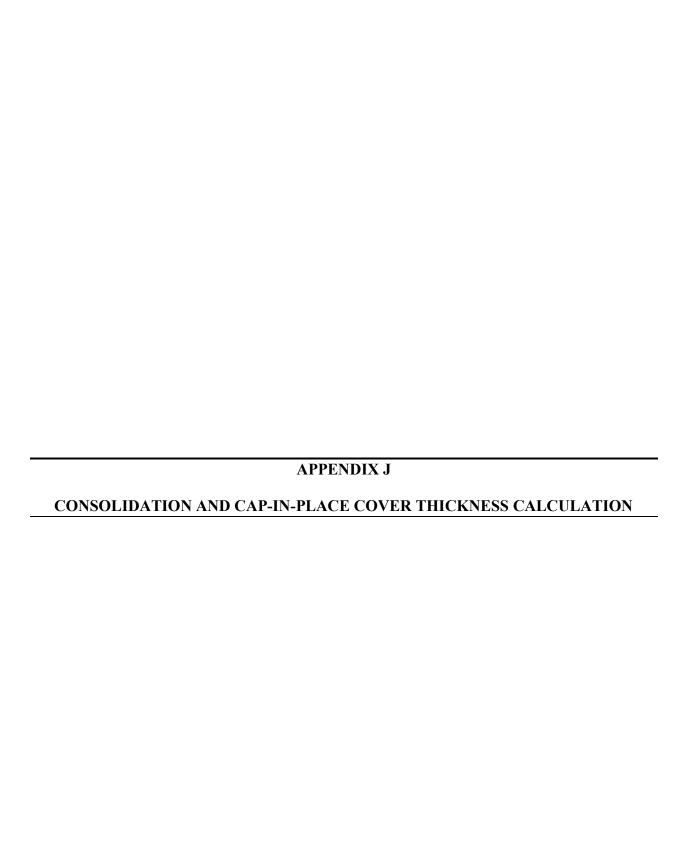


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<sup>&</sup>lt;sup>2</sup> Materials factor is based on the Gallup, New Mexico city cost index for Site and Infrastructure, Demolition (RSMeans, page 586).

<sup>&</sup>lt;sup>3</sup> Equipment factor is based on the Gallup, New Mexico city cost index for Contractor Equipment (RSMeans, page 635).

<sup>&</sup>lt;sup>4</sup> Time factor is based on adjusting 2016 cost data to January 2020, using RS Means Historical Cost Indexes (RS Means, page 612).



Variable	Resident Soil Default Value	Form-input Value
A (PEF Dispersion Constant)	16.2302	14.9421
B (PEF Dispersion Constant)	18.7762	17.9869
City (Climate Zone)	Default	Albuquerque, NM (3)
Climate zone	Temperate	Temperate
C (PEF Dispersion Constant)	216.108	205.1782
Cover thickness for GSF (gamma shielding factor) cm	0 cm	30 cm
Cover thickness for GSF , (gamma shielding factor) cm	0 cm	30 cm
CF <sub>recurreduce</sub> (contaminated plant fraction) unitless	1	1
CF <sub>recannel</sub> (contaminated apple fraction) unitless	1	1
CF <sub>recuendranie</sub> (contaminated asparagus fraction) unitless	1	1
CF <sub>rechery</sub> (contaminated berry fraction) unitless	1	1
CF <sub>res-broccoli</sub> (contaminated broccoli fraction) unitless	1	1
CF <sub>rec.hoot</sub> (contaminated beet fraction) unitless	1	1
CF <sub>rec-cabbage</sub> (contaminated cabbage fraction) unitless	1	1
CF <sub>recurring</sub> (contaminated cereal grain fraction) unitless	1	1
CF <sub>recuriture</sub> (contaminated citrus fraction) unitless	1	1
CF <sub>recurron</sub> (contaminated corn fraction) unitless	1	1
CF <sub>recurrent</sub> (contaminated carrot fraction) unitless	1	1
CF <sub>reculumber</sub> (contaminated cucumber fraction) unitless	1	1
CF <sub>rec-lettuce</sub> (contaminated lettuce fraction) unitless	1	1
CF <sub>rec-lima bean</sub> (contaminated lima bean fraction) unitless	1	1
CF <sub>recokra</sub> (contaminated okra fraction) unitless	1	1
CF <sub>reconion</sub> (contaminated onion fraction) unitless	1	1
CF <sub>recensach</sub> (contaminated peach fraction) unitless	1	1
CF <sub>recupe</sub> (contaminated pea fraction) unitless	1	1
CF <sub>rec_near</sub> (contaminated pear fraction) unitless	1	1
CF <sub>rec_notate</sub> (contaminated potato fraction) unitless	1	1
CF <sub>recummkin</sub> (contaminated pumpkin fraction) unitless	1	1
CF <sub>rec.rice</sub> (contaminated rice fraction) unitless	1	1
CF <sub>recense bean</sub> (contaminated snap bean fraction) unitless	1	1
CF <sub>recetramherry</sub> (contaminated strawberry fraction) unitless	1	1
CF <sub>res-tomato</sub> (contaminated tomato fraction) unitless	1	1

Cover Thickness Input = 30 centimeters

Variable	Resident Soil Default Value	Form-input Value
ED <sub>mea</sub> (exposure duration - resident adult) yr	20	20
ED <sub>rescr</sub> (exposure duration - resident child) yr	6	6
EF <sub>resa</sub> (exposure frequency - resident adult) day/yr	350	350
EF <sub>resc</sub> (exposure frequency - resident child) day/yr	350	350
IFAP (age-adjusted apple ingestion factor) g	667520	667520
IFAS <sub>researti</sub> (age-adjusted asparagus ingestion factor) g	300300	300300
IFBE (age-adjusted berry ingestion factor) g	297990	297990
IFBR <sub>ros.adi</sub> (age-adjusted broccoli ingestion factor) g	251510	251510
IFBT <sub>res_adj</sub> (age-adjusted beet ingestion factor) g	245490	245490
IFCB <sub>roc.adi</sub> (age-adjusted cabbage ingestion factor) g	670530	670530
IFCG <sub>rec.adi</sub> (age-adjusted cereal grain ingestion factor) g	611800	611800
IFCI <sub>rec.adi</sub> (age-adjusted citrus ingestion factor) g	2573410	2573410
IFCO <sub>rocari</sub> (age-adjusted corn ingestion factor) g	468580	468580
IFCR <sub>res.arti</sub> (age-adjusted carrot ingestion factor) g	222390	222390
IFCU <sub>me.adi</sub> (age-adjusted cucumber ingestion factor) g	630140	630140
IFLE recadii (age-adjusted lettuce ingestion factor) g	271320	271320
IFLI <sub>rec.arli</sub> (age-adjusted lima bean ingestion factor) g	250250	250250
IFOK <sub>rac.arii</sub> (age-adjusted okra ingestion factor) g	222530	222530
IFON <sub>rec.arij</sub> (age-adjusted onion ingestion factor) g	164780	164780
IFPC <sub>roc.arij</sub> (age-adjusted peach ingestion factor) g	1043840	1043840
IFPE <sub>rec.adj</sub> (age-adjusted pea ingestion factor) g	315210	315210
IFPR <sub>rac_arti</sub> (age-adjusted pear ingestion factor) g	503370	503370
IFPT <sub>ree_adj</sub> (age-adjusted potato ingestion factor) g	1003170	1003170
IFPU <sub>roc.adj</sub> (age-adjusted pumpkin ingestion factor) g	548520	548520
IFRI (age-adjusted rice ingestion factor) g	572880	572880
IFSN <sub>res-adj</sub> (age-adjusted snap bean ingestion factor) g	434630	434630
IFST <sub>rec_adj</sub> (age-adjusted strawberry ingestion factor) g	336630	336630
IFTO <sub>rec_adj</sub> (age-adjusted tomato ingestion factor) g	624470	624470
IRAP <sub>ms-a</sub> (apple ingestion rate - resident adult) g/day	73.7	73.7
IRAP (apple ingestion rate - resident child) g/day	72.2	72.2
IRAS (asparagus ingestion rate - resident adult) g/day	39.3	39.3
IRAS <sub>res-c</sub> (asparagus ingestion rate - resident child) g/day	12.0	12.0

Variable	Resident Soil Default Value	Form-input Value
IRBE <sub>rec.a.</sub> (berry ingestion rate - resident adult) g/day	35.4	35.4
IRBE <sub>reco</sub> (berry ingestion rate - resident child) g/day	23.9	23.9
IRBR <sub>rec.a</sub> (broccoli ingestion rate - resident adult) g/day	32.0	32.0
IRBR <sub>rec.r.</sub> (broccoli ingestion rate - resident child) g/day	13.1	13.1
IRBT <sub>ree-3</sub> (beet ingestion rate - resident adult) g/day	33.9	33.9
IRBT <sub>resc</sub> (beet ingestion rate - resident child) g/day	3.9	3.9
IRCB <sub>res.a</sub> (cabbage ingestion rate - resident adult) g/day	92.1	92.1
IRCB <sub>mec.</sub> (cabbage ingestion rate - resident child) g/day	12.3	12.3
IRCG <sub>rec.a.</sub> (cereal grain ingestion rate - resident adult) g/day	76.0	76.0
IRCG <sub>mex</sub> (cereal grain ingestion rate - resident child) g/day	38.0	38.0
IRCI <sub>rec.a</sub> (citrus ingestion rate - resident adult) g/day	309.4	309.4
IRCI <sub>rec.</sub> (citrus ingestion rate - resident child) g/day	194.1	194.1
IRCO <sub>res.a</sub> (corn ingestion rate - resident adult) g/day	59.8	59.8
IRCO (corn ingestion rate - resident child) g/day	23.8	23.8
IRCR (carrot ingestion rate - resident adult) g/day	27.3	27.3
IRCR <sub>rec.</sub> (carrot ingestion rate - resident child) g/day	14.9	14.9
IRCU <sub>me.a</sub> (cucumber ingestion rate - resident adult) g/day	82.4	82.4
IRCU_me_ (cucumber ingestion rate - resident child) g/day	25.4	25.4
IRLE reca (lettuce ingestion rate - resident adult) g/day	37.5	37.5
IRLE resce (lettuce ingestion rate - resident child) g/day	4.2	4.2
IRLI (lima bean ingestion rate - resident adult) g/day	33.8	33.8
IRLI (lima bean ingestion rate - resident child) g/day	6.5	6.5
IROK <sub>mes.a</sub> (okra ingestion rate - resident adult) g/day	30.2	30.2
IROK (okra ingestion rate - resident child) g/day	5.3	5.3
IRON <sub>reca</sub> (onion ingestion rate - resident adult) g/day	21.8	21.8
IRON (onion ingestion rate - resident child) g/day	5.8	5.8
IRPC <sub>me.a</sub> (peach ingestion rate - resident adult) g/day	115.7	115.7
IRPC <sub>reex</sub> (peach ingestion rate - resident child) g/day	111.4	111.4
IRPE <sub>rec.a</sub> (pea ingestion rate - resident adult) g/day	35.4	35.4
IRPE <sub>rec.</sub> (pea ingestion rate - resident child) g/day	32.1	32.1
IRPR <sub>rec.a.</sub> (pear ingestion rate - resident adult) g/day	51.9	51.9
IRPR <sub>res-c</sub> (pear ingestion rate - resident child) g/day	66.7	66.7

Variable	Resident Soil Default Value	Form-input Value
IRPT <sub>res.a</sub> (potato ingestion rate - resident adult) g/day	127.8	127.8
IRPT <sub>res_c</sub> (potato ingestion rate - resident child) g/day	51.7	51.7
IRPU <sub>rec.a.</sub> (pumpkin ingestion rate - resident adult) g/day	64.8	64.8
IRPU <sub>res.r.</sub> (pumpkin ingestion rate - resident child) g/day	45.2	45.2
IRRI <sub>reca</sub> (rice ingestion rate - resident adult) g/day	73.2	73.2
IRRI (rice ingestion rate - resident child) g/day	28.8	28.8
IRSN <sub>rec.a</sub> (snap bean ingestion rate - resident adult) g/day	53.9	53.9
IRSN <sub>rec.</sub> (snap bean ingestion rate - resident child) g/day	27.3	27.3
IRST <sub>res.a</sub> (strawberry ingestion rate - resident adult) g/day	40.5	40.5
IRST <sub>ree_r</sub> (strawberry ingestion rate - resident child) g/day	25.3	25.3
IRTO <sub>rec.a</sub> (tomato ingestion rate - resident adult) g/day	80.3	80.3
IRTO <sub>rec.</sub> (tomato ingestion rate - resident child) g/day	29.7	29.7
MLF apple mass loading factor) unitless	0.000160	0.000160
MLF asparagus mass loading factor) unitless	0.0000790	0.0000790
MLF <sub>herry</sub> (berry mass loading factor) unitless	0.000166	0.000166
MLF (broccoli mass loading factor) unitless	0.00101	0.00101
MLF <sub>hoot</sub> (beet mass loading factor) unitless	0.000138	0.000138
MLF <sub>cabbage</sub> (cabbage mass loading factor) unitless	0.000105	0.000105
MLF <sub>cereal grain</sub> (cereal grain mass loading factor) unitless	0.250	0.250
MLF <sub>citrus</sub> (citrus mass loading factor) unitless	0.000157	0.000157
MLF (corn mass loading factor) unitless	0.000145	0.000145
MLF (carrot mass loading factor) unitless	0.0000970	0.0000970
MLF (cucumber mass loading factor) unitless	0.0000400	0.0000400
MLF <sub>lettuce</sub> (lettuce mass loading factor) unitless	0.0135	0.0135
MLF <sub>lima bean</sub> (lima bean mass loading factor) unitless	0.00383	0.00383
MLF <sub>Akra</sub> (okra mass loading factor) unitless	0.0000800	0.0000800
MLF (onion mass loading factor) unitless	0.0000970	0.0000970
MLF <sub>peach</sub> (peach mass loading factor) unitless	0.000150	0.000150
MLF <sub>pea</sub> (pea mass loading factor) unitless	0.000178	0.000178
MLF (pear mass loading factor) unitless	0.000160	0.000160
MLF (potato mass loading factor) unitless	0.000210	0.000210
MLF <sub>pumpkin</sub> (pumpkin mass loading factor) unitless	0.0000580	0.0000580

Variable	Resident Soil Default Value	Form-input Value
MLF <sub>rice</sub> (rice mass loading factor) unitless	0.250	0.250
MLF cnan hean (snap bean mass loading factor) unitless	0.00500	0.00500
MLF ctrawherry (strawberry mass loading factor) unitless	0.0000800	0.0000800
MLF <sub>tomato</sub> (tomato mass loading factor) unitless	0.00159	0.00159
TR (target cancer risk) unitless	1.0E-06	1.0E-04
F(x) (function dependent on U/U,) unitless	0.194	0.0553
PEF (particulate emission factor) m <sup>3</sup> /kg	1359344438	2370938158.760359
Q/C <sub>wind</sub> (g/m <sup>2</sup> -s per kg/m <sup>3</sup> )	93.77	29.359877603759233
A (acres)	0.5	500
Site area for ACF (area correction factor) m <sup>2</sup>	1000029 m <sup>2</sup>	1000029 m <sup>2</sup>
ED <sub>res</sub> (exposure duration - resident) yr	26	26
ED <sub>roc.a</sub> (exposure duration - resident adult) yr	20	20
ED <sub>rec.</sub> (exposure duration - resident child) yr	6	6
EF <sub>res</sub> (exposure frequency - resident) day/yr	350	350
EF <sub>rec.a</sub> (exposure frequency - resident adult) day/yr	350	350
EF (exposure frequency - resident child) day/yr	350	350
ET <sub>res</sub> (exposure time - resident) hr/day	24	24
ET <sub>ms.a</sub> (exposure time - resident adult) hr/day	24	24
ET <sub>ms.r</sub> (exposure time - resident child) hr/day	24	24
ET <sub>res.i.</sub> (exposure time - indoor resident) hr/day	16.416	16.416
ET (exposure time - outdoor resident) hr/day	1.752	1.752
GSF, (gamma shielding factor - indoor) unitless	0.4	0.4
IFA <sub>rec.arli</sub> (age-adjusted soil inhalation factor - resident) m <sup>3</sup>	161000	0
IFS <sub>res-arti</sub> (age-adjusted soil ingestion factor - resident) mg	1120000	0
IRA <sub>res.a</sub> (inhalation rate - resident adult) m <sup>3</sup> /day	20	0
IRA <sub>rec_r</sub> (inhalation rate - resident child) m ³/day	10	0
IRS <sub>rec.a</sub> (soil intake rate - resident adult) mg/day	100	0
IRS <sub>rec_</sub> (soil intake rate - resident child) mg/day	200	0
t <sub>rac</sub> (time - resident) yr	26	26
TR (target cancer risk) unitless	1.0E-06	1.0E-04
Soil type	Default	Default
$U_{_{\rm m}}$ (mean annual wind speed) m/s	4.69	4.02

Variable	Resident Soil Default Value	Form-input Value
U, (equivalent threshold value)	11.32	11.32
V (fraction of vegetative cover) unitless	0.5	0.5

Site-specific
Resident PRGs for Soil - Secular Equilibrium

Isotope	Ingestion PRG TR=0.0001 (pCi/q)	Inhalation PRG TR=0.0001 (pCi/q)	PRG	Produce Consumption PRG TR=0.0001 (pCi/q)	Total PRG TR=0.0001 (pCi/g)
Secular Equilibrium PRG for U-235	(P = g)	(p =g)	5.51E+02	(P = 1 g)	5.51E+02
Secular Equilibrium PRG for U-238	-	-	2.86E+01	-	2.86E+01

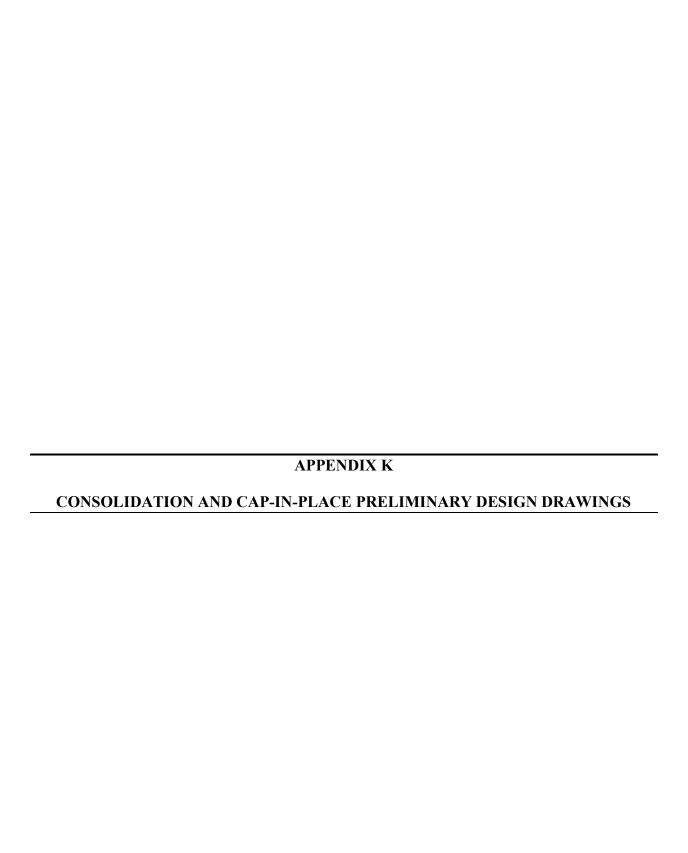
### **Resident Risk for Soil - Secular Equilibrium**

	•		•	Produce Consumption	Total
Isotope	Risk	Risk	Risk	Risk	Risk
*Secular Equilibrium Risk for U-235	0.00E+00	0.00E+00	3.83E-07	-	3.83E-07
*Secular Equilibrium Risk for U-238	0.00E+00	0.00E+00	1.85E-04	-	1.85E-04
*Total Risk	0.00E+00	0.00E+00	1.85E-04	-	1.85E-04

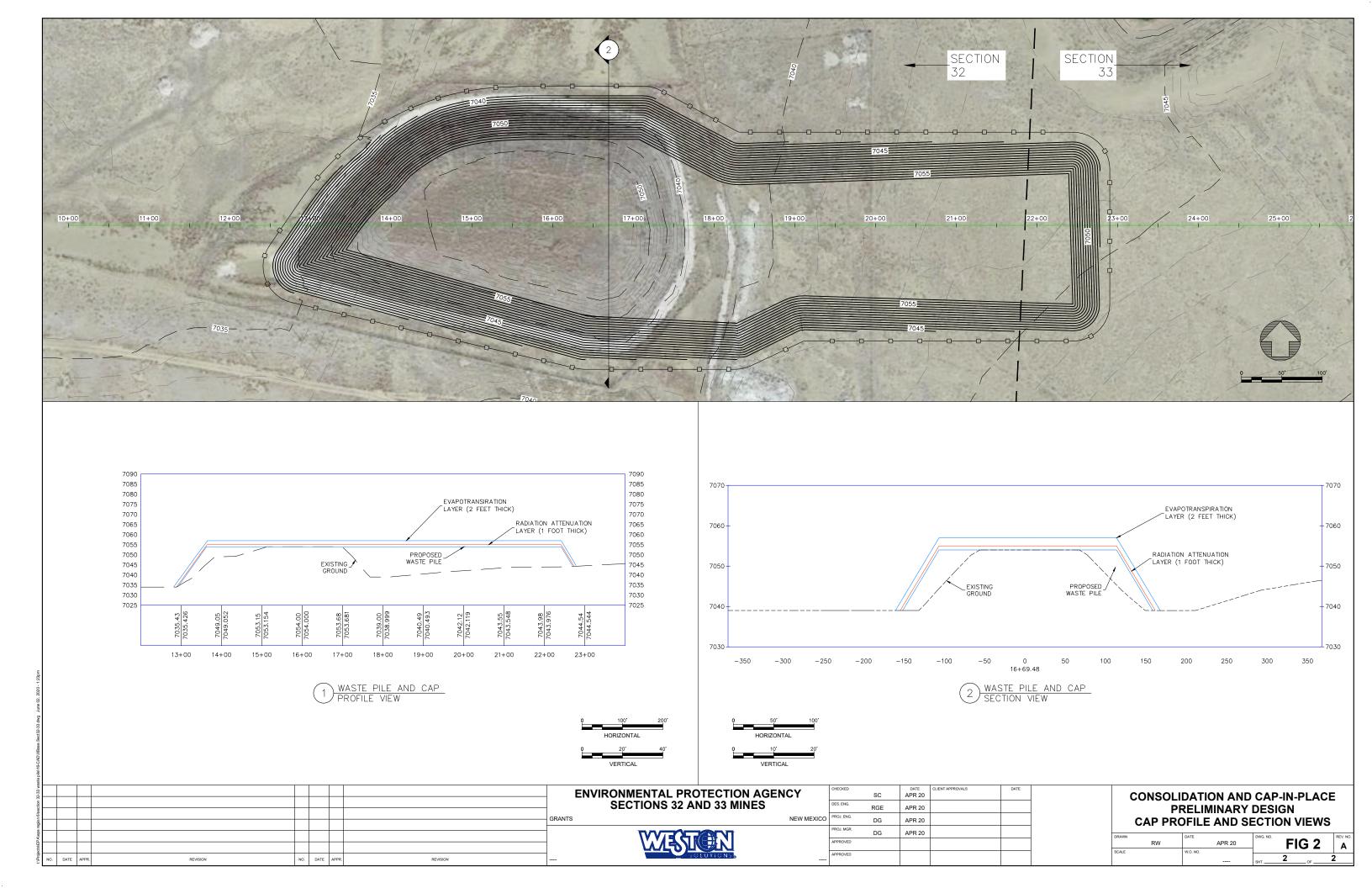
With a background risk of 1.3e-04 summed with the risk of 52.7 pCi/g Ra-226 with 30 centimeter [1-foot] clean cover of 1.85e-04, the total risk equals 3.15e-04 = 3x10-4 and is within the range that EPA manages cancer risk for radiological sites (2 to 3 x 10-4).

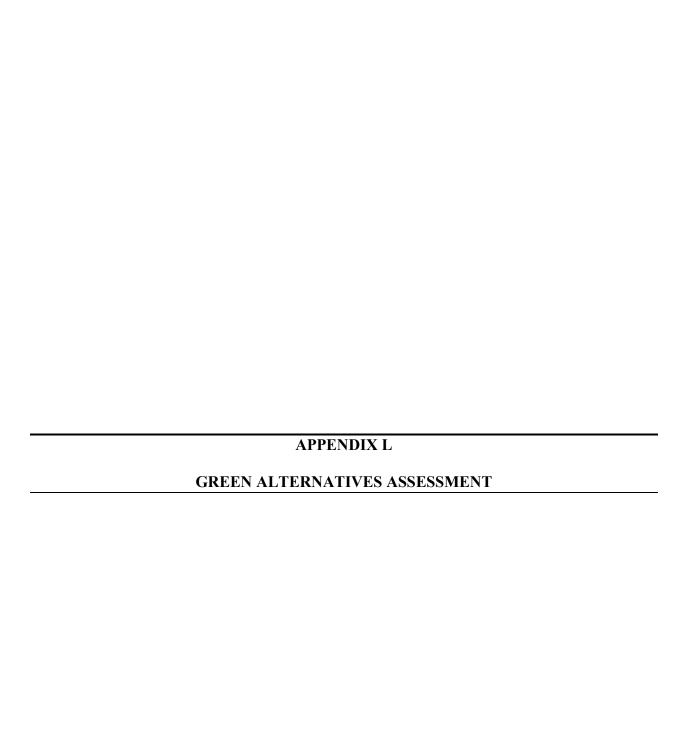
New Mexico Solid Waste Regulations in the NM Administrative Code (Title 20, Chapter 9), used as a 'To-be-Considered' (TBC), requires an additional 18-inch infiltration layer and a 6-inch erosion control layer of clean cover material; therefore, the total cap thickness for Alternative 3 Consolidation and Capping of Contaminated Soil in Place equals:

30 centimeters (1 foot) + 18 inches (1.5 feet) + 6 inches (1 foot) = 3 FEET









### 1 GREEN ALTERNATIVES ASSESSMENT

Based on EPA Guidance, there are five core (key) elements in "greener cleanup activities" that should be considered throughout the remedy selection process (EPA, 2016). These key elements include: minimizes total energy use and increases the percentage of renewable energy use; minimizes air pollutants and greenhouse gas emissions; minimizes water use and negative impacts on water resources; improves materials management and waste reduction efforts by reducing, reusing, or recycling whenever feasible; and protects ecosystem services (EPA, 2012). This analysis compares the effects each removal action alternative, described in Section 3.0, has on the five key "green" elements. Each of the five elements was scored qualitatively for each of the 3 alternatives using a numerical ranking system of 1-3, with a 1 being best and a 3 being worst (i.e., low scores are greener cleanup alternatives). The alternative's Greener Cleanup Assessment Score was derived from the sum of the five scores for that alternative. The results of this assessment are summarized in Table L-1. Alternative 3, Consolidation and Capping of Contaminated Soils in Place, scored the best (low score of 8) of the 3 removal action alternatives.

### 2 MINIMIZES TOTAL ENERGY USE AND INCREASES PERCENTAGE OF RENEWABLE ENERGY USE

Out of the three removal action alternatives, Alternative 1, the No Action Alternative is the only alternative that requires no energy. For the 2 other alternatives, energy usage can be broken into two main categories: electrical usage and direct fossil fuel combustion.

Alternative 2, Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility, and Alternative 3, Consolidation and Capping of Contaminated Soils in Place, have relatively low electrical requirements. The main electricity demands are expected to be for power to pump water from the onsite supply well, operation of the water treatment system to be constructed as part of the removal action, and for the office trailers brought in to support personnel; particularly for heating and cooling the trailers. Alternative 2 would have higher electrical demand than Alternative 3 since the off-site disposal facility would require additional



office support and water. Since active removal work is expected to be conducted during daylight hours, lighting requirements are expected to be minimal for all alternatives. The primary expected lighting needs would be during the darkest winter months, should work occur during those periods, to illuminate the on-site office trailer and equipment yards.

The greatest fossil fuel consumption will be for heavy equipment and trucks used during the excavation and transportation. Heavy construction equipment would be used to clear and grub, excavate, transfer, load, and grade the access roads, site, and impacted materials. Large dump trucks would be used to transport clean backfill to the site and for the transport and disposal of waste material. Alternative 2 has the largest fossil fuel demand due to having the greatest number of loads transported off-site and farthest distance to the off-site disposal facility. Alternative 2 also requires significantly more truckloads of clean fill material than Alternative 3 to backfill the excavation associated with disposal of contaminated soil. The transportation requirement of each alternative is summarized in Table 4-2.

The use of biodiesel, a renewable energy source, in place of diesel for heavy equipment use or transportation is recommended. Given that the ability to use biodiesel does not vary between alternatives and it is unknown if biodiesel fuels will be ultimately used, this analysis assumes heavy equipment will be operated using traditional petroleum-based fuel sources.

The alternatives rank as follows in order of least fossil fuel consumption to most: Alternative 1 (No Further Action), Alternative 3 (Consolidation and Capping of Contaminated Soils in Place, and Alternative 2 (Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility.

### 3 MINIMIZES AIR POLLUTANTS AND GREENHOUSE GAS EMISSIONS

Relevant air pollutants include greenhouse gases, nitrogen oxides (NOx), sulfur oxides (SOx), particulate matter less than 10 microns in size (PM10), and hazardous air pollutants (HAPs). Fossil



fuel combustion is expected to be the only source of HAPs as well as the major source of greenhouse gases, NOx, SOx, and PM10.

PM10 is generated during excavating and grading activities, including excavating material, hauling or otherwise handling excavated material, placing and compacting earthen materials, and driving on unpaved roads. Dust generation can be reduced through dust suppression methods, such as applying water, covering material in open trucks, using soil tackifiers, covering stockpiles, limiting on-site vehicle speed, and revegetating excavated areas as quickly as possible. Due to the factors discussed above, the air pollution emissions will be highest for alternatives that transport waste off-site.

As with energy demand, the greatest air pollution generation will be from the operation of heavy equipment during excavation activities and from trucks used to transport materials and waste. Estimated greenhouse gas emissions due to off-site trucking are summarized in Table 4-2. Thus, the ranking for air pollution is the same as for energy consumption. As with energy demand, Alternative 2 is expected to create air pollution that is an order of magnitude greater than the other alternatives due to the significant number of loads transported off-site and distance to the off-site disposal facility. The alternatives rank as follows from least air pollution generated to most: Alternative 1 (No Further Action), Alternative 3 (Consolidation and Capping of Contaminated Soils in Place, and Alternative 2 (Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility..

### 4 MINIMIZES WATER USE AND NEGATIVE IMPACTS ON WATER RESOURCES

Surface waters in the area are ephemeral and are generally only present for a day or two after rains occur during summer monsoon periods. Because of this, a local water source is unavailable; water demand will have to be meet with water trucked in from outside or by installing a well. Water use should also be considered as part of the energy demand transportation requirements and thus should be minimized both because of the impact on water resources and because of associated



increase in electrical and fossil fuel demands. The main use of water, regardless of which alternative is selected, will be for dust suppression and soil moisture conditioning to achieve the required relative density for compacted soil, followed by equipment decontamination. Thus, the alternatives with the highest excavation, consolidation, and transportation requirements will also have the highest water use.

Water use will not be the only impact on water resources. The creation of impervious caps reduces the infiltration of stormwater, resulting in higher peak flows in the receiving stream. The creation of engineered soil caps will temporarily increase runoff until vegetation is well established and final stabilization is achieved, which could take as long as 10 years. The higher peak flows will result in an increased risk of flooding and higher rates of erosion, which would impact water quality. This effect will increase in direct proportion to the footprint of any impervious cap. If the waste is disposed of at licensed facility, the size of the cap in relation to the volume of waste may be reduced due consolidation with waste from other sites. However, these facilities are also the most likely to use impervious caps. The risk of increasing peak flows can be mitigated by diverting the runoff for another use, such as irrigation, or to an area it can infiltrate into the ground, such as bioswales and stormwater detention basins. In addition to reducing infiltration, a cap can potentially change drainage patterns. However, this effect can be reduced by mimicking the slope of existing terrain.

Sediment runoff, particularly during excavation activities, can also degrade water quality during the project. Sediment runoff will increase nutrient loading and suspended solids in the receiving water. Since the sediment runoff would largely be from contaminated soil, another potential impact is the migration of radiation into nearby water resources. The greater the excavation footprint and duration of excavation, the greater expected impact. Sediment runoff can be minimized by avoiding excavation activities during the monsoon season, minimizing the amount of soil disturbed at a given time, and using sediment controls (e.g., reseeding bare soil as quickly as possible; installing silt fence, straw wattles and fiber rolls; and constructing stormwater detention basins). Migration of waste off-site through stormwater is a general concern for water bodies. With the



exception of Alternative 1, No Further Action, which involves no mitigation, all of the alternatives provide long-term mitigation of waste migration offsite.

Given all the factors outlined above, the alternatives rank as follows for minimization of water use and negative impact on water resources from best to worst: Alternative 3 (Consolidation and Capping of Contaminated Soils in Place, Alternative 2 (Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility) and Alternative 1 (No Further Action).

### 5 IMPROVES MATERIALS MANAGEMENT AND WASTE REDUCTION EFFORTS

Materials management and waste reduction efforts consider the total amount of materials used onsite and the percentage of those materials that are produced from recycled material, reused material, or waste material. Excluding fuels, which are evaluated separately, imported materials include the earth and rock materials in caps, geotextile fabrics, temporary fencing, silt fencing, culverts, large rock for riprap, and other water management and sediment and erosion control devices. The alternatives will all generate cleared vegetation in proportion to the amount of land disturbed. These factors are expected to apply regardless of which alternative is selected (i.e., whether on or off-site disposal of contaminated soils, all are expected to require varying amounts of the above materials).

Given these factors, the alternatives rank as follows for impact on materials management and waste reduction from best to worst: Alternative 1 (No Further Action), Alternative 3 (Consolidation and Capping of Contaminated Soils in Place, and Alternative 2 (Excavation and Off-Site Disposal at a Licensed Low-Level Radioactive Waste Facility.

### **6 Protects Ecosystem Services**

The negative effect on water resources described above is one of the ecosystem services impacts. Degrading water quality and quantity will affect the flora and fauna that depend on these sources.



Increased nutrient loading could cause algae blooms in downstream water bodies and increased suspended solids could inhibit stream life by blocking sunlight that allows photosynthesis. The more effective alternatives will be more protective of ecosystem services.

Given that Alternatives 2 and 3 do not disturb previously undisturbed areas, long term habitat degradation on land is unlikely for these alternatives. However, removal activities themselves will cause a temporary disruption to wildlife. Noise, ground disturbing work, and any artificial light can all impact sensitive species. To minimize these impacts, it is recommended to avoid conducting operations during nesting or breeding seasons whenever possible.

Given all the factors outlined above, the alternatives rank as follows for impact on ecosystem services from best to worst: Alternative 3 (Consolidation and Capping of Contaminated Soils in Place, Alternative 2 (Excavation and Off-Site Disposal of Contaminated Soils at a Licensed, Low-Level Radioactive Waste Facility), and 1 (No Further Action).

7 SUMMARY

A summary of the rankings for each of the core elements can be found in Table L-1. The table also presents an overall greenness score for each alternative. The score was calculated by summing the ranks each alternative received for each of the five core areas. The overall ranking of alternatives for greenness, from best to worse, are as follows:

Alternative 3 (Consolidation and Capping of Contaminated Soils in Place (Score: 8)

Alternative 1 (No Further Action) (Score: 9).

Alternative 2 (Excavation and Off-Site Disposal of Contaminated Soils at a Licensed Low-Level Radioactive Waste Facility (Score: 13).

USEPA REGION 6

### **8 REFERENCES**

USEPA. 2009. Principles for Greener Cleanups. August 27.

USEPA. 2012. Methodology for Understanding and Reducing a Project's Environmental Footprint. February.

USEPA. 2016. Memorandum: Consideration of Greener Cleanup Activities in the Superfund Cleanup Process. August 2.

### 9 LIST OF TABLES

Table L-1 Green Alternatives Assessment Summary



#### Appendix L

### Green Alternatives Assessment Tronox Navajo Area Uranium Mines, Sections 32 and 33 Mines McKinley County, New Mexico

Table L-1 Green Alternatives Assessment Summary

	Minimizes Total Energy Use and Maximizes Use of Renewable Energy	Minimizes Air Pollutants and Greenhouse Gas Emissions	Minimizes Water Use and Negative Impacts to Water Resources	Improves Materials Management and Waste Reduction Efforts	Protects Ecosystem Services	TOTAL
Alternative 1, No Further Action	1	1	3	1	3	9
Alternative 2, Excavation and Off-Site Disposal of Contaminated Soils at Licensed Low-Level RadioActive Waste Facility	3	3	2	3	2	13
Alternative 3, Consolidation and Capping of Contaminated Soils in Place	2	2	1	2	1	8

Note: The ranking scores of 1 through 3 represent Best to Worst relative to the 3 removal action alternatives, respectively. Thus, a lower score score represents a better green outcome Alternative 3, Consolidation and Capping of Contaminated Soils in Place, with a Total green assessment score of 8, ranks as the greenest removal action alternative of the 3 alternative: